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FOREST AND STREAM IN GUIANA.

THE STORY OF
FOREST AND STREAM

BY

JAMES RODWAY, F.L.S.

AUTHOR OF

"IN THE GUIANA FOREST," ETC.

WITH TWENTY-SEVEN ILLUSTRATIONS

LONDON
GEORGE NEWNES, LIMITED
SOUTHAMPTON STREET, STRAND
1897

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PREFACE

In another volume of this series Mr. Grant Allen has given "The Story of the Plants;" here I have attempted to give a few additional sketches of that larger field—the life of the trees in wood and forest. And, as water is so necessary to their well-being, and because without it there would be no forests, I have coupled the trees with the rivers. Living in the tropics and having come here after making observations in some of the woods and along a few of the streams of England, I have naturally made comparisons between the plant life of the old country and the grander flora of South America. Here the forest is a power to be reckoned with, for it comes to the front everywhere; even our gardens are thickets if left alone. I have attempted to picture this aggressive side of nature by giving the history of a coffee plantation which I have visited several times during the last few months. In temperate climates weeds hamper man's progress in utilising the soil for his own purposes; here the weeds are more frequently trees. By close observation of an English meadow in June no doubt the struggle for life among plants can be appreciated, but when, instead of grasses and herbs, we have trees of fifty feet in height, all straining to utilise the heat and moisture, by wresting them from their neighbours, the great battle is forced upon our attention. With a rainfall often amounting to eleven feet in a year and an almost uniform temperature of about eighty degrees, the conditions are favourable to an enormous development of energy. The tall papaw, which rises to a height of thirty feet, is as succulent as the cabbage, and the plantain is even more watery in the stem. These, and a multitude of soft-wooded trees, grow so quickly that in a year or so they cover the ground to the exclusion of less aggressive plants, and thus render the work of the planter very arduous. This aspect of the forest, however, is more fully dealt with in my "In the Guiana Forest"; here I have endeavoured to show the benefits derived by man and other animals from the forests and streams of every country.

J. RODWAY.

GEORGETOWN, BRITISH GUIANA,
October 1st, 1896.

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FOREST AND STREAM

CHAPTER I

BEAUTIFUL TREES

GILPIN, in his work on "Forest Scenery," written a century ago, said that a tree was the grandest and most beautiful of all the productions of the earth. Every tree is beautiful, and when standing alone each kind has its own character, or physiognomy, as it were. Some are so elegant and graceful that artists have rivalled each other in attempts to delineate them in different aspects, and the Greeks and Romans went so far as to deify them. Every part, from the trunk to the leaf, is in harmony with every other, and all go to make up the height of perfection. Trees in general are quoted as emblems of strength as well as of beauty; the sturdy oak is an example of resistance, and the trembling aspen of the character which bends but does not break. Both, in their way, are strong, and both stand firmly against the raging tempest. Even when gnarled and hollow a tree is still picturesque and an ornament to the landscape.

Winter takes off its verdant covering, yet the tree is still beautiful. The forking of branch and twig shows how graceful is its proportions, and lichens and mosses decorate its otherwise bare limbs. The hoar-frost and snow also

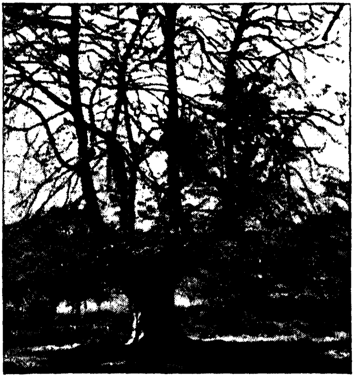
THE ASPEN.

produce the most wonderful effects, which are all the more interesting from their evanescent character. Then there are often decorations of ivy, woodbine, and clematis, which at this time have their ornaments of berries and feathery seeds.

Spring comes, and with it the tree puts on its new vesture. Now we can see the beauty of the leaf-buds, and distinguish their delicate tints as they unswathe and exhibit the infant foliage. What can be more lovely than a sprig of young oak-leaves gathered on King Charles' day? The common maple, also, and even the hawthorn, are lovely as they burst from their sheaths. The beech-leaves come forth white with silky down, and the pencils of the larch are accompanied by pretty, red catkins. We might go on to mention the willow, the poplar, the horse-chestnut, and, in fact, every woodland tree, for each has its own character in this as in other seasons. But in spring they take the place of flowers, and are almost as lovely as they.

Autumn has its glory in the beautiful tints which precede the fall of the leaf, and in the branches of coloured berries and fruits. Travellers have emulated each other in their praises of the glow of colour on the maple forests of North America. But at this season, as in spring, every species has its peculiar attraction. Even the oak, whose leaves turn brown and remain for weeks or months, exhibits its stubborn character as one who hardly appreciates the fact that he is suppressed for a time.

A tree standing alone is at liberty to develop its full and peculiar character, and in such a position is always typical of the species. The winds stir the foliage, now showing up the under-surfaces of the leaves, and then allowing them to fall back, every movement causing flickers of light on the ground beneath. When in flower

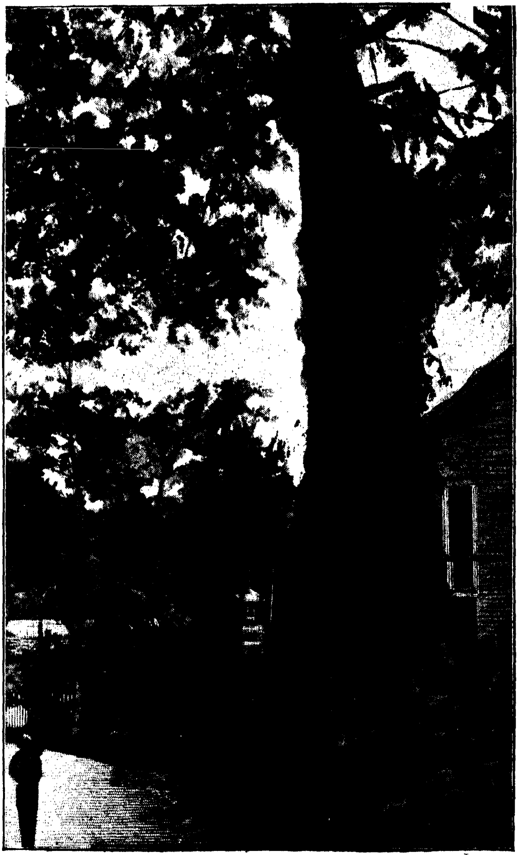


THE BEECH.

every puff of wind scatters a cloud of pollen to fertilise others at a distance, and when in fruit the birds assemble in its branches. In the meadow a single tree shelters the ruminating cattle, and man himself, like Virgil's Tityrus, loves to recline under the full-spreading beech.

If trees are pleasant to the eye in temperate climates, how much more so they must necessarily be in the tropics! Where the sun pours down his burning rays with an intensity hardly to be borne, and where the open plain glows with fervent heat, a canopy of foliage is at once grateful to the eye and to the feelings. A mango, a sandbox, or a tamarind affords a most effective shelter, but perhaps the best of all is the Saman (*Calliandra Saman*). Spreading to a great distance, its immense branches almost touch the ground, and its triply divided leaves effectually exclude the direct rays of the sun, while allowing sufficient light to fall on the sward beneath. The trees of the tropics also have their physiognomy. Some approach the laurel, and nearly all have thick rigid leaves which do not admit of those pretty effects produced by the wind which are seen in the beech and birch. The grace of the laurel is seen in such trees as the mammee-apple, but perhaps one of the handsomest of this type is the star-apple, which has the under surface of its leaves covered with a ruddy down.

Although these leaves are thick, their stalks allow some movement, and in a strong breeze the dark green of the upper surfaces is variegated with the ruddy brown of the under part. The branches spread and arch gracefully over, and the whole tree is free from the somewhat stiff laurel-like appearance of many other trees. Then there is the Terminalia, the radiating branches of which form a series of tables one above another at intervals, each a little smaller than that below. The "Long John" (*Triplaris Americana*) is another graceful tree which towers to an immense height, but without spreading, from whence its shuttlecock-like seeds are seen at certain seasons gracefully descending. But the most stately of all is undoubtedly the silk-cotton tree—the ceiba—which stands head and shoulders above all the rest. In general appearance it is a gigantic oak, with branches as large as some of the finest trees of Europe. A full-grown specimen is an object in the landscape, and can be seen from a long distance above the otherwise level forest canopy. Near the ground its buttresses stand forth to form great alcoves, each of which is a fair-sized chamber. At eighty to a hundred feet above the ground come the branches, forming a magnificent dome which is often decorated with the hanging nests of the cassiques, besides a wealth



THE CEIBA IN A GARDEN.

of bush ropes and epiphytes. But the trees of equatorial regions are so many and varied that to even enumerate them would require a volume.

We must not, however, forget the flowers. In other climes there are horse-chestnuts, false acacias, magnolias, laburnums, and many others, which brighten the landscape at their flowering seasons; here we have the queen of them all, the *flamboyant* (*Poinciana regia*). Rather low in stature, the branches extend in the form of a great bouquet, covered with delicately beautiful foliage, finely divided, at one season, and with a canopy of fire at another. And this is not an evanescent glory, like that of some trees, which comes to-day and is gone to-morrow; the Poinciana lasts for several weeks. The Saman also is exceedingly beautiful in flower, its branches of rosy-tinted stamens forming a most lovely foreground to its canopy of foliage. The *Lagerstrœmias* deserve the name "Queen of Flowers," which has been given to one of the species, for their mauve blossoms make a grand show. Bright yellows are conspicuous in the etabally (*Vochysia*), *Cassia multijuga*, and several other leguminous trees. The coral-tree (*Erythrina*), as its name denotes, has orange-scarlet flowers, which, although not so glorious as those of the *flamboyant*, shine brilliantly in the sunlight. Blue is not very common, the nearest approach to that colour being the Jacaranda, the trumpet-shaped flowers of which are usually borne on naked branches after the leaves have fallen.

A large number of trees bear inconspicuous flowers, but these appeal to another sense than that of sight. Their odours are borne upon the wind, especially at night, until an evening walk becomes pleasant for this reason alone. But even these trees are not suffered to remain undecorated, for the climbing bignonias and convolvuli often cover them with festoons and crowns of glory.

In the tropics, also, the palms, "the princes of the vegetable kingdom," come to the front. The "glory of the mountains" (*Oreodoxa*) is perhaps the grandest, and well worthy the name of "Royal Palm." As straight as a pillar it stands a hundred feet in the air, and, notwithstanding its feathery capital, defies the wind to either bend or break it. Like the exogenous trees, every species of palm has it own character. Artists have given the cocoa-nut stem a line of beauty hardly justified by nature, for rarely indeed does it bend in such graceful curves as is represented. Unlike the Oreodoxa, it is flexible, and, growing on the sea-shore, is liable to be bent back by the wind. But it is by no means defeated. It appears to know that its best position is one where it can face the breeze, and, however twisted, it always brings its head round again, thus giving the stem a series of turns and producing an irregular spiral. These two are examples of palms with pinnate foliage, but there are fan palms quite as handsome; in fact, it is hard to say which form of leaf is the most beautiful. Possibly the most elegant are those which have flexible leaves; some of these have the under surfaces white, which undoubtedly makes them more pleasing as they wave in the wind.

Emerson said that "trees are imperfect men," and the truth of this is becoming more evident every day. Every living thing has powers and capacities only differing in degree from the others. The germ of the oak was once a single cell, indistinguishable from that which went to form the bird which perches on its branches. The two main objects of life, the procuring of food and preserving of the line of continuity, is common to both. To say that a plant is not conscious of its existence is obviously going farther than the evidence will permit, for it certainly has feeling, which is at least the forerunner of consciousness.

That trees have been worshipped in several countries is not wonderful when we consider that the Greeks and Romans venerated beauty

PALMS IN AN INDIAN CLEARING.

of form in both nature and art. The first temples were groves of trees; the priests of Apollo performed their sacred rites under the laurel. This was sacred. A Greek would hold a leaf in his mouth to charm away misfortune, and his diviners used it to instil within them a spirit of prophecy. To the Roman it was an emblem of victory; conquerors returning home wore the laurel-wreath, and the soldiers in the procession bore sprigs in their hands. The college degree of bachelor (*baccalaureus*) is derived from the custom of crowning successful orators and poets with it. According to Ovid, when Daphne fled from the embraces of Apollo, she called upon the earth to alter her form, and she was changed into a laurel. On seeing this transformation the god exclaimed, "But since thou canst not be my wife, at least thou shalt be my tree; my hair, my lyre, my quiver, shall have thee, O laurel! Thou shalt be presented to the Latian chieftains when the joyous voice of the soldiers shall sing the song of triumph, and when the long procession shall resort to the Capitol."

India has her sacred fig, a tree allied to the banyan, which, like most of the family, is very beautiful; and, coming home to Britain, we have the oak, which was also sacred in ancient

Greece, and which was no doubt connected with the myths of the dryads. Under this tree the mystic rites of the Druids were performed; its leaves were woven into chaplets and its timber used to keep up the sacred fires.

THE OAK.

Possibly, also, the wearing of the leaves on the 29th of May is as much a relic of the old religion as a commemoration of the escape of Prince Charles. The mistletoe of the oak and the yule log were sacred, and even the modern use of the former may have had its origin in some old British rite.

The African has his fetish tree, the ceiba, which we have already mentioned as a magnified oak in appearance. In Africa offerings are still made to it as a god, and even in the West Indies religious rites are sometimes performed under its shadow. Few of the blacks can overcome their feeling of reverence so far as to cut it down, and, if they do so, must first pour a libation on its roots.

CHAPTER II

FORESTS AND THE SEASONS

Besides their beauty as individuals, trees have special attractions when grouped, but above everything comes the grandeur of the wood or forest. Where this is made up of deciduous trees its appearance changes with the seasons. In spring, before the sunlight is obstructed by foliage, the ground is covered with beds of anemones and wild hyacinths, and then also the trees are alive with birds. In summer the canopy is too dense for flowers to open in the recesses, but alongside the paths and in the glades many a little beauty can be picked up; this also is the time for delightful walks in the shade. Autumn is full of stir and rustle, leaves falling on every side to spread a brown carpet over the ground, which every wild animal stirs as he runs over it from an intruder. Even the pine-woods, although sombre and monotonous, have their charm, not the least part of which is their delightful odour.

Sylvan beauty has been appreciated from very early times; perhaps before people began to see anything to admire in frowning precipices and lofty mountains. Our oldest English ballads praise the "merry greenwood," and Shakespeare takes us into the forest in some of his most interesting scenes. Towards the end of the last century the picturesque side of woods and forests began to be more and more appreciated, until some painters made a speciality of woodland scenes. Many of us can recall the forest rambles of some past time as among the pleasantest memories of our lives.

But if the woods of temperate climes are lovely, how much grander and more dignified are the forests of the tropics! In Europe and North America the species are few; under the equator they are almost innumerable. Nearly every plant is tree-like, even when their stems are softer than the lowly weeds of other zones. The depths of the forest are dark and monotonous, it is true, but the edge of the swamp and the banks of rivers and creeks are entrancingly beautiful. It is a common saying that "variety is charming;" here we have nature revelling in a thousand different forms. Rarely do trees of the same kind grow together; every one is distinct from its neighbour. There are a few exceptions, however; notably fringes of

IN THE DENSE FOREST.

eta palms on the borders of the savannahs, the advance-guard of the dense forest. Their rugged stems, crowned with clusters of waving fans, make a fit setting for the great field of tall sedges, while here and there on little islands groups of two or three break the monotony of this wide expanse.

The beauty of grouping, however, is best seen on the banks of the narrower rivers, called creeks. Where the streams are very broad the forest slopes down into the water, into which it is extended for some distance by thorny bushes, mocca-moccas (*Montrichardia arborescens*), and floating island grass (*Panicum elephantipes*). Nothing but this bank of foliage can be seen here, but on the creeks the tall trees meet overhead, leaving only a few gaps here and there, where perhaps one of them has lately fallen. In one place our bateau passes through a tunnel, and in another through an intricate Moorish gateway of bush ropes. Then we come to a leaning tree, or a branch covered with epiphytes which hardly allows us room to pass. The creek winds in great bows and loops, every bend bringing a new picture into view.

Here can be seen most lovely examples of grouping. Perhaps the most graceful of all is the manicole palm (*Euterpe oleracea*), its cluster of stems rising from twenty to a hundred feet

ETA PALMS, RAVENALIAS, AND MOCCA-MOCCAS.

or more, here and there one standing above every tree of the forest, while others are just peeping above the ground. Yet the trunk is hardly more than six inches in diameter, this slender column bearing a crown of flexible leaves which hang down and wave with the least motion of the air. Then there is the Bactris, its stem and leaves triply armed with darning-needles, which forms impregnable clumps that are continually expanding in every direction. The pretty and more delicate Geonoma, the smallest of our palms, with stems no larger than walking-sticks, also makes a lovely group, and over some of the trees and bushes hangs that sprawling monster the Desmoncus, with a double row of hooks at the end of every leaf.

Whether the palms are exceeded in beauty by the bamboo is doubtful, but a large clump of this has a lightness and grace hardly to be excelled. And what shall we say of the tree ferns, a group of which is simply perfection? And what of the Heliconias and Marantas, those broad-leaved plants which form such an admirable contrast to those with more delicate foliage? Even the mocca-mocca, with its arum-like leaves on tall stems, is always handsome. These, however, are not, strictly speaking, the trees of the forest; they tower above our heads and interlock to form the dense canopy, under which their trunks can be seen like the pillars of some interminable building. Here and there a stately mora (*Mora excelsa*) rises above the undulating surface, but most of the others are lost in the expanse of foliage. Looking up, we try to distinguish one species from another, but this is rarely possible. Here are the fallen petals or capsules of a monkey-pot (*Lecythis*), and there the great pods of some leguminous tree, but it is hard to say from whence they fell. Many a species remains to be identified by the botanist, and even some of the timber trees are only known to the woodcutter.

THE MOCCA-MOCCA (*Montrichardia arborescens*).

Although there are no real deciduous trees in the tropical forest, all have their seasons of flowering and fruiting—their spring and autumn. The struggle for existence is so fierce that no remission is possible, and consequently most of them perform double the work of their cousins in the North. Instead of one great task in the year, they must accomplish two; two springs, two summers, two autumns, but no winter or time of rest. A large number distil their perfumes after sunset when flowering; at that time, therefore, they do not even rest at night. In spring the flowers and leaves appear, the latter quickly pushing off the old foliage; then comes the longer season for ripening fruit; and finally the short fall, which precedes another cycle.

Winter gives a season of rest to nature generally; without it trees do not sleep. In fact, they dare not, for their rivals are always ready to take advantage of every patch of sunlight that might enter if one of the number remained bare for a few days. Underneath is a litter of seeds, not one of which can ever gain a place as long as the canopy is unbroken; but once allow the sunlight to reach them, and soon a host of rivals would come to the front. Their parents have been straining for years to gain positions where they may blossom and ripen their fruit; all their strength has apparently been spent for nothing. But this is really not the case. Myriads of seeds are produced only to feed the birds, beasts, and fishes, but here and there one finds an opening, where it can rise and take part in the great struggle.

Although spring is a very short season in the tropics, it still has its charm. There is no contrast between bare twigs and young leaf-buds, but the delicate new foliage comes forth glowing with tints even more lovely than that of the oak. Some are membranous and limp, almost transparent for a few hours, and during this time they have a delicacy of shading that would kindle enthusiasm in an artist. Soft creams, blush pinks, olive greens, and ruddy browns are all changing quickly to the mature greens of their predecessors. In our gardens we can watch this development in the case of the mango. The long leaves hang loosely at first and are of a warm liver-colour, then they change to brown, to green with a ruddy tint, and finally to the usual dark green. The fine foliage of the tamarind is an example of another type which is delicate and pretty, with its touch of pink, which harmonises so beautifully with the flowers. But the tree cannot afford to linger; the change is quickly over, and perhaps in a day the new leaves can hardly be distinguished from the old.

Here and there, also, we have something like the coloration of autumn. The Terminalia, the seaside grape, and the fiddle-wood denude themselves more gradually than most others, and before the leaves drop they change to most gaudy tints of scarlet and yellow. These are, however, the exceptions; in most cases the change is too sudden for autumn to be perceptible. And then again, from the absence of that mighty factor, warmth after cold, two trees of the same kind are rarely at the same stage together. Every one is an individual, and as such it chooses its own time—it may be a week or two earlier or later than its neighbours, but not altogether without times and seasons, as some writers have asserted.

There are other great differences between the trees of torrid and temperate climates which are apparently necessary to the existence of both. Where in the former the bark and leaves are generally thick and juicy, in the latter they are thin and dry. The great pine family seems to be specially protected against cold by its secretions of resin and turpentine; other secretions, such as indiarubber and essential oils, are no doubt beneficial in hot climates. A curious result of these differences is, that the forests of North America are easily set on fire, while those in the South not only refuse to be kindled while alive, but form the best protection against the destroying agent. After a drought, when the grassy savannah, like the prairie, is easily kindled, the surrounding forest is never burnt. A few branches may be scorched, but the tree is not seriously injured. Again, when the Guiana

Indian makes a clearing by chopping down the trees over a small area, to be burnt a few months later, there is no risks to the surrounding forest. A great flame rises, and the heat is intense, but rarely indeed is a tree on the borders injured, much less destroyed. We have seen the stumps in such a clearing throwing up new stems close to the charred surfaces, thus proving that their power of enduring heat is at least as great as that of the pines to bear its opposite.

The story of the earth, as told by its fossils, goes to prove that ages ago forests like those of the tropics extended almost to the poles, and no doubt a struggle for life as unremitting as that going on here to-day was common everywhere. Trees shed their leaves, as they do still, only when prepared for a new vesture, which they put on in a few days. Even in this there would have been no uniformity except in case of a drought. With the change of climate everything was altered; winter checked the growth, and nothing was left but a long rest, until the warmth of spring caused the grand awakening.

What a wonderful contrivance is this shedding of leaves! When in its full vigour the leaf is a part of the whole tree, and to tear it off causes a wound. But when the time comes for a change it drops easily, leaving a mark, it is true, but no sign of real injury. Denude a tree at other times, and it evidently suffers; it bleeds, it may even die.

When the great cold of the North first came upon the earth hundreds of species of trees must have been exterminated. Some, however—perhaps those which lived on the mountains—were enabled to endure the change. They came down from amidst the snows and settled in the warmer valleys, to form the nucleus of the Northern flora of to-day. To prove that something like this took place, we may examine the trees now to be found on the higher mountains, such as the Himalayas and the Andes, where we can still find representatives of orders and genera which are otherwise confined to temperate regions.

What took place on these mountains can be seen to-day on some of the barren hills of the tropics. A long dry season or a drought comes; the trees drop their leaves slowly, and wait for the rains to fall before renewing them. The ground is too dry for the host of rivals to germinate, and they can safely rest for a month or two. Cold has a similar effect; frost, like drought, is uncongenial, and the trees strip themselves until the warmth of spring again rouses them to activity.

Seeds and tubers also lie dormant during the winter, and since they have become accustomed to such a rest they are injured when prevented from enjoying it. The tubers of Dahlias and other garden flowers never do well in the tropics after their first flowering; they sprout again before their time, and become weaker and weaker, until they ultimately die. Man, who does not sleep during the winter, requires a store of food, and this property of tubers and some fruits is a great convenience to him. The food-supply in the warm regions, however, is almost continuous, and is soon spoiled. Fruit must be eaten when ripe, perhaps within a few hours, and yams and sweet potatoes will not keep good for any great length of time. There is little use for storehouses and barns, for there is virtually nothing that can be kept long enough to make them desirable.

And here we have another beautiful provision of nature. Apples ripen at a particular season, and then for a long time no more can be obtained; the mango trees, by their individual differences, produce the result that this fruit can be obtained more or less for about six months in the year. The continuous struggle of the trees tends to produce variation, not only in species, but in individuals as well. The result is a want of uniformity; long extensions of the fruit seasons, which are of the greatest consequence to both man and beast. For where fruit cannot be preserved, it is of importance that it should not all ripen at one time.

One of the most beautiful sights of a Northern spring is an orchard in full blossom. The leaves have not yet appeared, and every tree is a canopy of white or pink flowers. How beautiful, and yet how evanescent! All the trees are flowering at the same time, and in a day or two nothing will be left but a litter upon the ground. It is commonly reported that orange-trees bear flowers and green and ripe fruit at once. This statement, although a little exaggerated, is to a certain extent true. But, nevertheless, there are flowering and fruiting seasons—seasons when oranges, mangoes, and guavas are plentiful, and times when they can hardly be obtained at any price. Between these periods a tree here and there will still have a few fruit, and thus prevent a long dearth.

It can easily be seen that this is a most convenient provision for the birds, bats, and other frugivorous creatures, as well as for man. Tropical seeds, or rather their coverings, cannot be preserved, and therefore they are produced throughout the greater portion of the year. First, the two cycles of seasons produce a double crop, and then the individuality of each tree tends to lengthen the time, until it follows that some can be obtained during eight months in the year.

From observations made in Guiana it appears that the mango and bread-fruit seasons last from June to August and from November to February, the largest crops generally coming in July. In 1889, however, the great mango season fell in February and March, when the number brought to market exceeded that of any other season we have on record. As a rule the two seasons are unequal, but the causes for this (possibly climatic) are at present very uncertain. The general result of these and many other observations is to prove that the flowering and fruiting seasons in Guiana are fairly regular. Spring comes about the beginning of March, and again in August or September, and these (the flowering periods) are immediately followed by a summer of about five months, after which autumn merges again into the other spring. It can easily be understood that at the transition period a tree may be flowering while a few ripe fruit still remain to give reason for the statement that flowers and fruit are often borne at the same time.

On the borders of the tropics there must be places where the two cycles begin to be merged into one, but as yet we have little information on this matter. We have been informed, however, that in the tropical islands of the Pacific the bread-fruit has its two fruiting seasons, while on the verge of the warm regions, where there is something approaching to winter, only one crop is produced in the year.

CHAPTER III

FOREST AND STREAM

If we ask ourselves what it is that makes a landscape so pleasing to the sight, the answer must necessarily be, first, its covering of vegetation, and, second, water in the form of brooks, rivers, and lakes. Mountains and rocks are imposing, and cataracts force themselves on our attention by their deafening noise, but in the absence of a setting of green or clumps of trees, they are lifeless. It is the earth "with verdure clad" which appeals to the mind, and which does so much to promote the higher civilisation. The snow-bound and ice-clad earth of the North and the burning sands of the desert soon become monotonous and dreary, and the wilderness of houses in a great city produces a weariness which only the open fields and woods can relieve. The love of trees and flowers is instinctive in the child, and as the man slips down the hill of life he often returns to his first love.

The meadow, with its wealth of grass and

BESIDE A STREAM ON A MOUNTAIN.

flowers; the moor, yellow with furze or broom; and the mountain-side glowing with heather, all show the effect of a covering to the bare earth or rock. But when we come to clumps of trees, woods, and forests, how much grander is the result! A mountain with bare, frowning precipices has certainly a majesty of its own, but were it without a covering of lichens it would be almost repellent. With here a tree, there a handsome group, and a grove on the slopes, however, the aspect is softened, and the whole forms a pleasant landscape, only requiring water to complete the picture.

Springs are largely the result of vegetation. How often do we find the sources of rivers embowered in trees, and how much they add to the beauty of such spots! Take, for example, one of those English brooks that spring from the sides of the chalky downs. Down in the valleys many a crystal stream comes sparkling from its little arch, each embowered by a few bushes or trees, which relieve the monotony of the green carpet around. Where they unite there is sure to be a little coppice or wood, and beyond, the little river spreads out in the valley, to flow through a bed of reeds and cotton-grasses. Then there is the trout-stream, which often springs in the recesses of some wood to wind in and out among the trees before it comes to the open country. The beauty of "fairy glens" and waterfalls is also mainly due to overhanging vegetation, and the banks of rivers and margins of lakes are rendered all the more agreeable by a few trees. And is not much of the loveliness of English scenery due to its woods, parks, and hedges? In viewing a stretch of country from some lofty hill the effect is that of a great forest, in which the fields are little more than open glades. How different were there no trees! Cultivated fields, llanos, and prairies have no doubt a beauty of their own, but this cannot be compared with that of the woodlands.

Even in the midst of the prairie the course of a river is shown by a double line of trees: is there not some connection between them? Is the river due to the forest or the forest to the river? Experience goes to prove that springs are conserved in a well-wooded country, and that they dry up if a great clearance is made. It has also been stated that tall trees attract rain-clouds and electricity, and are therefore responsible for many a local thunderstorm. Such storms often occur at seasons when the regular rainfalls, due to the great air-currents, are absent, and when, therefore, they are doubly useful. In Guiana it is certain that thunderstorms are more common over the forest than over the

ON A CREEK.

sea, and we almost invariably see the black clouds moving from the coast and getting darker and darker as they approach the line of bush. On the one side it may be said that a heavy rainfall is due to the forest, and on the other that trees certainly cannot grow without water. As a matter of fact the interdependence is so very close that both are causes and both effects, according to the way we look at them. To assert, therefore, that one single factor is the foundation of every other is assuming what is unwarranted by the evidence, yet the removal of this one may be as disastrous as the fall of the keystone of an arch. Forests affect the climate and rainfall of a country; these again act and react upon each other to make it habitable for man, beast, bird, and insect.

What is the result of denuding a land of its forests? Almost certainly barrenness! Rain may fall in the usual quantity, yet, from the want of masses of vegetation, it will do harm rather than good. Great floods denude the unprotected surface until nothing remains but bare rock, sand, or clay. A deluge comes to-day; it runs off and leaves the surface to be baked by the burning sun to-morrow. The truth of this has been verified by experience on several small islands: when they were clothed with forest, water was plentiful;

when denuded, droughts became frequent and disastrous.

The island of St. Helena was once covered with trees, but partly from wood-cutting, and partly from the ravages of goats, the rocks were laid bare. The result was serious droughts, which occasioned great losses of cattle and crops. Towards the close of the last century, however, strenuous efforts were made to restore the vegetation, with the result that in late years the condition of the island has been much improved.

In Mauritius, during the ten years following 1852, about seventy thousand acres were denuded. Several rivers became diminished in volume, and droughts were troublesome. And this was not all, for floods were more disastrous, and the alternation of drought and deluge, together with the partial drying up of swamps, produced sickness. Dr. Rogers, writing in 1871, said that until lately the island was one mass of verdure. "But when the forests were cleared to gain space for sugar cultivation, the rainfall diminished; the rivers dwindled down to muddy streams; the water became stagnant in cracks, crevices, and natural hollows; while the equable temperature of the island entirely changed; drought was experienced in the midst of the ocean, and thunder-showers were rarely any longer witnessed. The lagoons, marshes, and swamps along the seaboard were no longer filled with water, but gave off noxious gases, while the river waters became impure from various refuse. After a violent inundation in February 1865, followed by a period of drought, fever of a low type set in." These serious results led to attempts at replanting, and after about a million trees had been restored, the rivers and streams began to attain their former dimensions.

The name of Madeira was given on account of the island being so well wooded when first discovered. Those who saw it in that condition spoke highly of its loveliness. The country was delightful, the forests stately and magnificent, the trees were laden with excellent fruit. The waters were cool and limpid, and in the interior was found a beautiful sheltered meadow, bordered by laurels and refreshed by a mountain-stream which ran sparkling over pebbles. Dr. Graham, in his work on the "Climate and Resources of Madeira," says that on its discovery it presented a most lovely picture; the majestic cedar, the laurel, the till, and other trees forming one continuous and impenetrable forest, from which issued innumerable springs of sparkling and salubrious water. But a great fire swept the island, after which there came changes, although some tracts of forest still remained to prevent its becoming altogether sterile. On the eastern side of the basin of Funchal, the capital, the heights have been almost cleared of trees, with the result that here the rain-water comes down first in an impetuous torrent, and then in a tiny stream; to dry up entirely after a day of sunshine. Some attempts have been made to restore the forest, with encouraging results.

The island of Curaçao, once beautiful with gardens and plantations, is now little better than an arid waste, yet the great South American forest lies but sixty miles away on the mainland. Here is a field for experiment which as yet does not appear to have been commenced. The Cape de Verde Islands are also suffering through the destruction of their forests, droughts making them little better than deserts. Examples could be found of similar results from denudation, not only in small islands, but in large tracts of country in Greece, Italy, Spain, and France. Probably the barrenness of Palestine is due to the same cause; the land once described as "flowing with milk and honey" is now little more than a barren waste.

Perhaps the most interesting example is the island of Ascension, which appears to have been little more than a barren, arid rock when discovered. It was first occupied after the removal of Napoleon to St. Helena in 1815, and at that time the water-supply hardly sufficed for the garrison. It depended on drip from the volcanic rocks and rain-water collected in a few tanks. Three ox-carts were continually employed to bring this poor supply a distance of six miles, and after a long drought it almost entirely failed. Borings were at last made and a better supply obtained, with the result that a little could be done in the way of cultivation. In 1861 a large still for sea-water was erected, and with this accession further progress was made in planting trees and shrubs, all of which had first to be grown in nurseries and watered by hand. The result of all this care and attention has been almost wonderful. Dr. J. D. Hooker, who visited the island in 1843, said that but one tree existed upon it, and that owing to the want of water hardly enough vegetables for the Commander's table could be raised. In 1865 there were thickets of over forty kinds of trees, besides shrubs and fruit-trees; the water-supply was excellent, and the garrison, as well as ships calling on their voyages, could be supplied with vegetables.

Marsh, in his treatise on "The Earth as Modified by Human Action," gives the following graphic account of the results of denudation:—

"All is changed. At one season the earth parts with its warmth by radiation to an open sky; receives at another an immoderate heat from the unobstructed rays of the sun. Hence the climate becomes excessive, and the soil is alternately parched by the fervours of summer and seared by the rigours of winter. Bleak winds sweep unresisted over its surface, drift away the snow that sheltered it from the frost, and dry up its scanty moisture. The precipitation becomes as irregular as the temperature; the melting snows and varied rains, no longer absorbed by a loose and bibular vegetable mould, rush over the surface and pour down the valleys seawards instead of filling a retentive bed of absorbent earth, and storing up a supply of moisture to feed perennial springs. The soil is bared of its covering of leaves, broken and loosened by the plough, deprived of the fibrous rootlets which held it together, dried and pulverised by sun and wind, and at last exhausted by new combinations. The face of the earth is no longer a sponge but a dust-heap, and the floods which the waters of the sky pour over it hurry swiftly along its slopes, carrying in suspension vast quantities of earthy particles, which increase the abrading power and mechanical force of the current, and, augmented by the sand and gravel of falling banks, fill the beds of streams, divert them into new channels, and obstruct their outlets. The rivulets, wanting their former regularity of supply and deprived of the protecting shade of the woods, are heated, evaporated, and thus reduced in comparison with their former currents—but swollen to raging torrents in autumn and in spring."

But with all this we must not forget that the barrenness of a country has often been the salvation of its people. The civilised races of antiquity did not arise in the great forest regions of Germany and Italy, but rather in open countries. Egypt owed its prosperity to natural and artificial irrigation, and the gardens of Babylon and Assyria were purely the result of man's handiwork. The centres of the Roman and Greek Empires were by no means the most fertile parts of their dominions, and no doubt the struggle to overcome this barrenness helped to make the people strong and brave. A powerful nation is the outcome of a struggle of some kind, either with nature or its human rivals. If pleasure alone were the great consideration, then every trouble and difficulty is an evil; but if, on the contrary, happiness is allied to inertia and death, work of all kinds means force, power, and advancement in individuals as well as in nations. But work to be useful must be performed to some good purpose; we should not denude a country for the purpose of restoring its fertility by the labour of centuries.

Apart from man's influence, however, nature is by no means backward in her efforts to undo his desolating work. Undoubtedly, she is much hampered and delayed in the case of small islands, when they have once been entirely denuded; yet sooner or later grass and weeds cover the bare ground, and in the end woods and forests arrive upon the scene. The conditions necessary are warmth and moisture, with protection from man and beast.

After complete denudation, which, however, is of rare occurrence except from fire, frost and thaw, sun and rain begin the work of preparing a thin covering of soil on the barren clay or rock. Soon a film of green moss or brown lichen begins to appear, and these prepare the way for higher vegetation. They gather and retain the moisture which falls in the forms of dew and rain, and in a manner prevent the sun from having its full effect. Then in their process of growth they break up the surface of the rock or of the hard soil, until they crumble to form a thicker covering of mould, to which is added fine sand and organic matter in the form of dust. These processes seem very paltry when we look at the tiny moss or lichen, the latter upon the sides of a wall, and the former on the top; but when the cushions of a tortula or screw moss are examined, they will be found to have gathered quite an appreciable quantity of soil.

The work of these minute plants can best be seen on what is called a dry wall—a structure of limestone without mortar. When taken from the quarry the bare stones are perfectly sterile, in fact chemically so. Yet they do not remain bare for any length of time, for with almost the first rains a shade of green begins to appear on the exposed portions. This shows that the lower orders of plants are germinating, and soon we can see the characteristics of lichen and moss on the sides and top. When these have gathered sufficient soil, the top in spring becomes decorated with the tiny whitlow grass (*Draba verna*) and the breakstone (*Saxifraga tridactylites*), to be replaced later by cushions of stonecrop and other plants. From the crevices come the navel wort and ferns, or perhaps the whole side is festooned with cranesbill and toadflax. Every plant gathers something to add to the soil of this pretty rockery, and in time we may perhaps see an elm-tree sprouting from one of the lower crevices.

At first sight it seems rather absurd to call a little plant an inch or two high Saxifraga, the stone-breaker, yet this insignificant weed by no means belies its name. In its way, perhaps, the lichen is more deserving of the appellation, but the tiny plants with hair-like roots undoubtedly penetrate every crack, and ultimately fracture the stone until it crumbles. This can be seen in the west of England by careful observation on every dry wall, but in the tropics we have stone-breakers that force themselves upon our attention.

In Guiana, where houses are built upon brick pillars, the action of sun and rain often crumbles the cement and affords an opening for the wild fig, the seed of which has been carried there by some bird or bat. It germinates in the rainy season, and in a few weeks its fibres have begun to swell into leech-like aerial roots, which accommodate themselves to the cracks and fill them up. Now commences the great work of the stone-breaker. The roots expand, loosen one brick after another as they ramify, and if left undisturbed endanger the whole foundation of the building. When young, hardly any plant can be more soft and delicate, yet its possibilities are enormous. It will strangle a tree, break down the chimney of a sugar building, change a brick vault into a heap of rubbish, and even crack a marble slab. Its power of leverage is hardly credible ; every tiny crack is the opening for its insinuating wedges, and nothing in the way of masonry can long endure in its presence. And then it is so common, for its fruits are so palatable to the birds and bats, and the seeds pass through their bodies not only without hurt, but rather with benefit.

These are some of the vegetable cultivators of the soil, but we must not forget the work of the animals. Darwin has shown, in his work on "Vegetable Mould and Earthworms," what an influence the despised worm has on the soil. In nearly all moist countries these soft-bodied creatures are not only numerous but powerful. In some parts of England they turn over and pass through their bodies every year about ten tons of vegetable mould to the acre. From the falling in of the old burrows, which help when open to drain the soil, the mould is slowly but surely kept moving, thus exposing fresh surfaces to the action of the acids of the soil, as well as to the air. Thus the particles are subjected over and over again to conditions highly favourable to decomposition, and even the softer rocks are triturated in the gizzards of the worms.

The finely levigated castings, when brought to the surface, are washed over it by the rains, or, when dry, blown about by the winds, and thus evenly distributed to form ultimately a layer of rich soil. A layer one-fiftieth of an inch thick is thus annually brought up from below, and it is only a matter of time for this to result in that covering which first allows grass to grow, and ultimately trees.

In concluding his work, which was almost a revelation, Mr. Darwin says :—

"When we behold a wide turf-covered expanse, we should remember that its smoothness, on which so much of its beauty depends, is mainly due to all the inequalities having been slowly levelled by worms. It is a marvellous reflection that the whole of the superficial mould over any such expanse has passed, and will again pass, every few years through the bodies of worms. The plough is one of the most ancient and most valuable of man's inventions; but long before he existed, the land was, in fact, regularly ploughed by earthworms. It may be doubted whether there are many other animals which have played so important a part in the history of the world as these lowly organised creatures."

In the forest worms are not so plentiful as in the meadow, and in many hot countries they are comparatively rare even in the fields and gardens. In Guiana the hard clay and interlacing roots of trees on the higher ground are far from being congenial to them, and we do not remember seeing the sign of a worm under the dense canopy. Again, in the river-bottoms and on the flat coast lands the sourish condition of the ooze is equally distasteful, which confines them to cultivated grounds, where, however, they are by no means plentiful. At first sight this will appear to be a drawback, but when we see how strong are the roots of the commonest weeds, and how they penetrate the driest clay, the absence of these cultivators is felt to be of little consequence. There is a greater tendency here also for roots to run over the ground, where they are covered by the layer of dead and decaying leaves, under which the terminal fibres not only find a shelter but a continual supply of moisture and food.

And here again we have a beautiful provision of nature for breaking up organic matter. In the forests of North America the ground is often so littered with dry branches and twigs, that travelling through them is difficult from this cause alone. In the tropics there is very little of this sort of encumbrance; in fact, most of the dead branches are broken up before they fall. Now and again we come upon some giant lying at full length, and over which it appears as if we must climb to get past. But at the pressure of our foot the apparently hard timber crunches like a pile of egg-shells, and the whole tree is seen to be nothing but a collection of galleries and chambers, with paper-like partitions, filled with termites or wood ants. These are the agents by which the fertilising layer is being continually renewed. Individually more insignificant than the earthworm, the termite breaks down the largest trees until they turn into that rich brown humus so characteristic of the forest as distinguished from the open country. More numerous than worms could possibly be in the dampest climate, they are at work everywhere above our heads, but except the dark oval masses which form their headquarters and the numerous lines of what appear like streaks of dirt running over trunk and branch, nothing is visible. They are too weak to bear even the half light of these recesses, but nevertheless their work is going on night and day. If a tree is wounded to death they are always at hand to remove the corpse, but they apparently do no harm to the strong and healthy. Instead of the rotten branch falling to be broken up by heat and moisture, it is passed through the bodies of the termites, to ultimately come down as dust, together with the flakes of what were once partitions to the vast assemblage of tunnels and chambers.

CHAPTER IV

CONSERVATION OF MOISTURE

No doubt there was a time when the earth was bare, and when something like what we have been describing as the result of nature's handiwork took place. At first nothing stood in the way of the rushing torrents which followed a heavy downpour of rain. The streams washed away the surfaces of the rocks as fast as they crumbled and carried the detritus into the valleys, making it impossible for anything to grow in the more exposed situations. But there were always sheltered corners and hollows, and in these vegetation appeared, to ultimately cover almost the whole earth. Every plant did a little with its fibrous roots to arrest the rain as it fell; the whole covering acted as a sponge until the torrents were bridled; finally rivers became perpetual instead of intermittent, and man could build towns in the valleys without danger from flood or drought.

Floods are undoubtedly more disastrous and more common where the land is uncovered. The amount of rain may not be as great in the open as over the forest, yet its effects will be more perceptible. The field is always drier than the wood, which can easily be proved by the dampness of the soil under a single tree. Even a hedgerow retains a large proportion of the rain which falls, and wherever there is a covering of soil the water runs off slowly, and is therefore more beneficial.

Humus is always more or less hygroscopic; it attracts aerial vapour at night even in the driest seasons. When bare the result is not so appreciable, but when covered with turf it is almost wonderful. This may be seen on the barren chalk-hills of England, where a carpet of green sward covers what would otherwise be glaring mounds and tablelands, almost unbearable to the eye when the sun is shining. How arid they become when ploughed up, and how poor the crops! The country is undoubtedly more beautiful when they are utilised for sheep-walks, and rarely will they pay for cultivation. The result is unprofitable after a year or two, and then the fields remain bare and ugly for a very long time.

If these few inches of turf conserve moisture, how much grander is the effect of the network of roots in the forest! To this must be added the litter on the surface, which is always damp. True, this mat of humus, fibres, and fallen leaves parts with its water, but it does so very slowly. The rain which falls upon an open road runs off or dries up at once; the drainage from a meadow continues much longer, but the brook which rises in the wood is often perpetual. Even bare rocks become hygroscopic in the shade, when those outside may be burning hot to the touch.

The ever-flowing river is something different from the watercourse, which is dry at one season and an impetuous torrent at the next, and it is of the greatest importance to agriculture that the water-supply should be continuous. What occurs when such is not the case is seen in many parts of Australia and South Africa. Flood and drought alternate; at one time sheep and cattle are carried off by inundations, at another they die of starvation and thirst. If forests check these evils, then we cannot say too much in their favour.

When a large tract of country is bare, the rainfall finds its way at once into the gullies, and the rivers take the nearest possible course to the sea; in the forest the trees set up barriers in the shape of great clumps of roots, which have to be coasted. The result in the latter case is a winding course, which naturally allows the irrigation of a larger extent of country. In

ON A GUIANA RIVER.

Guiana the forest creeks and rivers wind about in such a manner that they often almost turn back upon themselves. We have often paddled for twenty-five miles over great loops, where the distance in a straight line would have hardly reached eight, and in some cases, by drawing the boat over a narrow isthmus, a whole day's journey may be saved. Every bend is necessarily a check to the current; it keeps the river from running dry, and helps the weary paddlers in their arduous work of pulling against the stream. Rocks and boulders also act as checks; without these and the trees our rivers would often run dry. How impetuous some of these are in the rainy season may be judged from the fact that the same distance may be easily accomplished in a week, with the stream, that has taken over a month's hard work against it.

How the trees work can easily be seen in our narrow creeks. A seed sprouts on the bank, and as it grows, extends a cluster of roots into the water. By-and-by this encroaches farther and farther, checking the current until it impinges upon the opposite bank. The creek is narrowed until some great flood rises; then the weakest comes to grief, and the narrow gorge becomes a broad bend. This is continually going on, and as continually the course of the stream is changing, the general result being a series of checks, and at the same time new openings are made for the seeds of forest trees which continually come down with the flood.

When a flood inundates the forest, and indeed even when it covers a meadow, a filtering and depositing goes on, which adds much to the fertility of the soil; this is especially the case when the obstructions to its outflow allow time for subsidence. Such a covering of silt has a wonderful effect on the richness of a country as compared with the consequences of a rushing torrent with no such checks. The grinding power of water was undoubtedly useful in the early stages of the world; then nothing but a few lichens and sea-weeds could exist on land or in the water. With a bare earth no doubt the rainfall was enormous, for the water would disappear very quickly; the clouds discharged themselves, and almost immediately again became loaded with evaporated moisture. Then began that great disintegration of the rocks, the result of which we see in beds of clay, sand, and pebbles, so plentifully distributed all over the earth. No doubt the first checks to the impetuous torrents were given by the rocks and boulders which obstructed their paths, but these would be

INSIDE THE FOREST.

gradually worn away, and only when vegetation came to the front could the earth be made habitable to man and other animals.

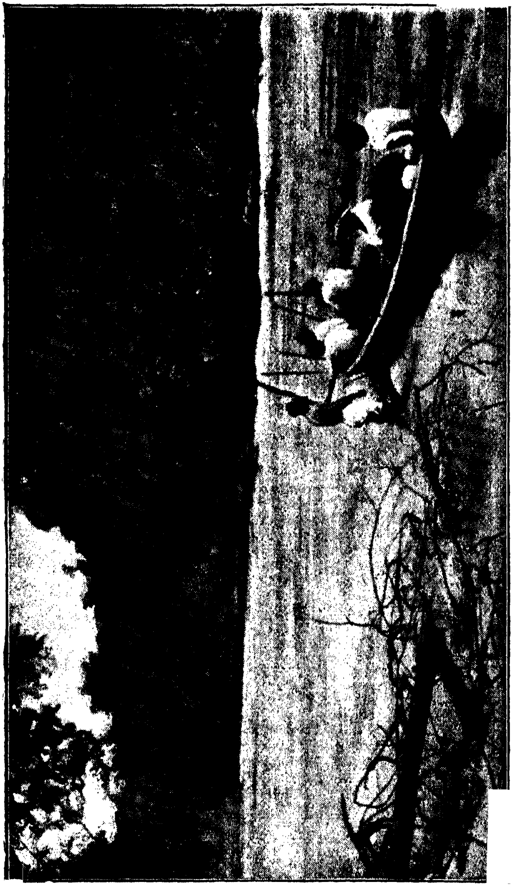
In the earliest historical periods forests were more common and extensive than they are at present. In every great tract of country where the rainfall was abundant there were either woods or swamps, and these were interchangeable. This can be easily proved by the existence of coal-beds and peat bogs, where alternate strata of vegetable remains and sand or clay show the effect of water. Then the remains of great trees—the bog oak timber—found beneath the peat, makes it certain that water sometimes destroys the forest. Here is an example of what we are continually finding in nature; the same agent is at one time an enemy and at another a friend.

In temperate climates the inimical effect of water can be seen on badly drained lands everywhere, but to see this in perfection we must go to the tropics. On the flat lands of the coast of Guiana great floods are common, and the drainage is the most important work on a plantation. Few cultivated plants can endure a flood for more than a day or two; in this respect they differ much from the trees of the forest, which often stand up in the midst of pools for half the year. If such were not the case large tracts would be destroyed every rainy season, for the great rivers rise to a height of thirty or even forty feet above their lowest levels.

But even here there is a limit to the endurance of a flood. Rain falls sometimes to the amount of ten inches in one day; the banks of the rivers and creeks are undermined, and trees are carried away to accumulate in some narrow place and form a dam. During the dry season they become consolidated under water, for here the termites cannot reach them, to be shortly covered with and interlaced by vegetation, which collects and roughly filters the water which passes through. Silt of all kinds chokes the passage until a dam is formed, on which the floating grass weaves its strong meshes. This is continually getting larger and higher until the passage is effectually checked, or perhaps closed altogether, and the water behind spreads over a large area. In this swamp which is now forming, the trees can exist but for a little time; one after another dies, and is either disposed of by the termites or else falls into the water. Then a great clearing is seen, which quickly becomes a reedy savannah, looking like a meadow, but with water below to a depth of three to six feet.

Meanwhile the outlet of the creek has been stopped. Where once flowed the powerful current is gradually encroached upon by moccamoccas, marantas, and prickly palms, all of which enlarge their clumps by the addition of suckers. Floods come, but the barrier still remains, only permitting the water to flow over when it rises higher than the dam, and, if no outlet is found, the savannah encroaches further upon the forest until perhaps it may stretch for miles in every direction. Decades, and even centuries, may pass; the former creek-bed is indistinguishable from the forest below or the swamp above. Then perhaps comes an extraordinary flood, which either breaks away the barrier or opens a channel in another direction. The imprisoned water bursts forth, carrying devastation in its path. Great trees fall before it and are swept along like straws in a brook, ploughing the surface of the ground, and forming battering-rams to overthrow everything in their path. Every now and then the accumulated flotsam is too great for the stream and it has to turn aside, thus making the new creek as winding as its predecessor. Now that the channel is excavated, the water flows from the swamp, trees again appear, and very quickly it becomes a second time incorporated with the forest.

All the tropical rivers have bars at their



mouths, and these may in some cases become dams. The stream is much diminished in the dry season, and the bar is hardly covered. In some places it appears above the water, and on the sand or mud may be seen thousands of tree seedlings, rapidly coming up to assimilate the place to the stretch of forest that fringes the shore. For, unlike the coast in temperate climes, where only a few low weeds can endure the salt spray, trees in the tropics not only grow on the shore, but extend for some distance into the shallows. The courida (*Avicennia nitida*), the mangrove (*Rhizophora Manglier*), and several others are at home on the margin of the sea, and they form living dams more durable than the earthworks and fascines of the engineer. As the couridas grow upon the bar they extend their perfect mats in every direction until perhaps a long island is formed, which drives the now weakened current to divide and flow out at either end. Floods come and round off this island, but do not carry it away, and ultimately it becomes habitable for man.

A glance upon the map of South America will show that the mouths of the great rivers Amazon and Orinoco are broken up by innumerable islands, between which the stream finds a hundred channels. These channels are continually being altered, and this is mainly the work of the courida. Without the trees no doubt sand-banks and mud-flats would exist, but with them we get the forest. In other tropical regions similar results are produced; in the Pacific the work is done by the cocoa-nut palm.

In North America, and long ago even in Europe, beavers formed dams in the woods similar to those we have been describing. By bringing down logs and placing them in position, they checked the stream, and formed quiet pools behind, where they might erect their homes in peace. In England mill-dams produce similar effects; the water spreads out to form a bog or marsh, which is often the only locality in the neighbourhood where the botanist can find such plants as sun-dews.

From all this it may be easily understood that forests are very important factors in the conservation of moisture, and therefore in making the earth habitable. They not only arrest the flow of water, but sometimes stop it altogether, and in this way bring about changes which are undoubtedly beneficial, although perhaps at first sight they may appear to be disastrous.

CHAPTER V

FORESTS, RAINFALL, AND THE DARK WATERS

METEOROLOGISTS are not agreed as to the effect of forests on the rainfall; statistics appear to show that they hardly increase or diminish it to any great extent. The rainy and dry seasons of a country undoubtedly depend more upon the great air-currents, such as trade-winds, than upon local conditions; yet it is quite certain that local rains are often due to large areas of woodlands. Mountains and hills are well known to influence the rainfall, as is shown by statistics; perhaps the most notable instance is that of the Andes, which arrest the rain-clouds as they pass, and make some parts of the west coast of South America nothing better than arid deserts. That forests also cause precipitation from clouds which have passed over the plain is equally certain; in fact, it is easily conceivable that when clouds are low any disturbing influence may have a similar effect to the strings put in syrup to assist crystallisation, or to the agitation of a vessel of water when cooled below the freezing-point. As a chain of mountains may have more rain on the windward side, so also may the edge of the forest where it rises from the sea or from the plain. On some low wooded islands, even where they are only two or three miles across, the difference between windward and leeward is perceptible, while that between the coast and the forest of Guiana is enormous. A drought may be prolonged on the plantations, while thirty miles off rain may be falling every day.

But, besides these effects, which may be considered as mechanical, there are other reasons for believing that trees have a great influence on the rainfall of a country. It has been estimated that the summer evaporation of a wood in one day is equal to over an inch of rainfall on its whole area. By placing the branch of an oak in water and noting the quantity of liquid taken up, it was calculated that a full-sized tree would absorb from the soil and give off into the air two tons of water per day. This may possibly be an exaggerated estimate, because evaporation will necessarily depend a great deal upon the dryness of the atmosphere and the amount of moisture about the roots; yet the fact remains that trees are continually at work distilling water in enormous quantities. Given air already charged almost to the point of saturation, it is easily conceivable that the slight addition made when it passes over the forest will at once cause precipitation.

Harland Coultas, writing on "What may be Learned from a Tree," said that "the ocean, winds, and woods may be regarded as the different parts of a distillatory apparatus. The sea is the boiler, in which the vapour is raised by the solar heat; the winds are the guiding tubes which carry the vapour to the forests, where a lower temperature prevails. This naturally condenses the vapour, and showers of rain are thus distilled from the cloud-masses which float in the atmosphere by the woods beneath them." This refers to the action of forests in producing discharges from the clouds, but, as we have seen, it only represents the case from one standpoint. The trees also are stills; they add their quota to the vapour brought from the sea, and this very act of distillation makes every forest a great refrigerator.

Suppose we divide the rainfall of a country into three parts, one of these will go to water the ground, another percolates to form springs, while the third flows off at once to fill the watercourses. These portions will vary much at different seasons; at one time the ground will be so highly saturated that the water will all run away to cause floods, at others the ground will take up the whole and crave for more. Then there will be differences in the retaining power and the capacity for percolation of various soils. According to its permeability or absorbing power, so will it retain a larger or smaller portion of the rainfall. Then comes the inclination, which has so much to do with drainage, and without which, and without outlets, bogs and morasses would take the place of fertile ground. Although it is desirable that the rainfall should not pass off too quickly, at the same time the channels must be free to prevent sourness.

Here again comes in the work of the forest. Take an uneven piece of ground, say a wood or a meadow in winter, when the grasses and trees do little in the way of distillation. It is sodden and oozy. The sun has little power to dry it up, and the plants have even less. But examine the same place in a rainy June and the difference is enormous, although perhaps the amount of precipitation is greater. A little moisture has lodged on the leaves, to be dried by the sun, but this is only a fraction of the whole, which has gone into the soil, as it did during the winter. Yet the ground is comparatively dry, and will hardly take the impression of your footstep. In the one case vegetation is active; in the other dormant.

There is a great difference between the amount of water distilled by grasses as compared with trees, but the former are by no means contemptible. Trees not only conserve moisture, but they drain the soil through every pore of their leaves. During the heavy rains we can see that they are hard at work; new leaves are being put forth, so that every possible effort may be made to find outlets for water which might injure the roots, if allowed to remain too long. Under the trees the ground is rarely sodden, but away from their influence this condition is indicated in Guiana by what is called the sour grass (*Paspalum conjugatum*). In the wet season it is rampant everywhere but under the trees or within the area of their root-extensions, and wherever it flourishes the ground is oozy. Compared with the trees this grass does little in the way of drainage, but it has certainly accommodated itself to conditions very unfavourable to the other members of its family, and is typical of the aggressive weed.

Evaporation always reduces temperature, and therefore this distillation tends to produce a more equable climate in the tropics. On the treeless plains the sun pours down with fervent heat, until the sands or baked earth become almost unbearable to the feet, even when protected by boots. The barefooted Indian shields his soles with strips of bark when journeying over such places, for otherwise they would be blistered. The glare on the white sand under the noonday sun is so intense that the eyes cannot endure it, and in the distance the air vibrates above the surface as it does over molten metal. Yet even here there are clumps of bushes and some low wiry plants, the roots of which penetrate to cool depths, where water is stored after the rains. All these plants have accommodated themselves to their environment, but they do not flourish like the trees of the forest. Still, they must do something to make the sand-reef less arid, for, like the others, they are continually distilling a little moisture to prevent their own utter annihilation.

Where the rain goes that falls upon the sand-reef can be easily seen on the edge, as it slopes down into the forest or river. Here a hundred little springs come trickling down amidst a dense jungle of palms, marantas, and tree-ferns, all struggling with each other for places under such genial conditions. As long as this vegetation is allowed to remain the springs continue, however arid the season; but were it removed the sun would dry them up almost immediately, until the rains again fall.

TREE-FERNS ON A HILL-SIDE.

The water from the sand-reef is bright and colourless; that from the swamp and forest a dark brown, but clear like weak coffee. Almost every river in South America looks black in the shade, for which reason several have been named Rio Negro. This colour is produced by the rain-water washing over and percolating through the dead leaves and humus, or from infusions of the dry sedges which grow so thickly in the swamp. When the rain falls heavily on the forest it runs down the trees in little streams, or comes from the leaves in great drops, to form a thousand tiny brooks, which, being more or less obstructed on their way to the creeks and rivers, are rarely dry. They gradually pass through the obstructions, and in doing so get tinged with the colour of the humus.

A few rivers rise from the edge of the sand-reef, and for a distance may remain untinged, but in the end they are almost sure to get some of the dark water either from forest or savannah.

Evaporation makes the forest cooler by day and warmer by night than the open country. The difference on the sand-reef is most striking. About thirty miles up the Demerara river, where the sand beach, which in some former age must have been the coast of Guiana, begins to rise, a traveller feels chilly towards morning. On the other side of the river, where the forest is more dense, you may sleep comfortably, but on the sand an insidious cramping sensation, which the negroes call cold, wakes you up in the small hours of the morning. Then the great splashes of dew from the trees above your head, and the damp feeling which pervades hammock, blanket, and clothing, make a camp-fire grateful. But it is not really cold; the thermometer registers at its lowest only 68° Fahr., and you may yet have the same chilly feeling when it is not lower than 75°. How exceedingly damp the air must be is shown by the fact that a straw hat becomes limp, and that the sliding-frame of a camera cannot be moved. Cheap cabinet work that has been glued comes to pieces, and boots and books become mouldy. This is all changed when the sun gets up, and drives you away from the glare of white sand to take refuge in the forest.

But the forest also is very damp at all times. Where in the open this is only perceptible at night or in rainy weather, under the shade it is almost uniform. When we bring forest plants, such as orchids and ferns, into our gardens, they will only flourish under glass; the climate of the moist warm conservatory is congenial, because it approximates most nearly to that of their homes.

As may be supposed, rain falls more often at night. A stratum of saturated air may pass over the open country, or even the forest itself, to fall on the sand-reef. Sometimes the dry season on the coast of Guiana is prolonged, while not a day may pass in the forest region without a shower. Radiation from the sand lowers the temperature, so that vapour held in suspension may be precipitated by the difference of only two or three degrees thus produced. Such rains are generally accompanied by lightning; and sheet-lightning is so common over the forest region in the dry season that it is looked upon by the residents of the coast as a sign of dry weather.

The peculiar reek of the tropical forest is appreciable to the senses of smell, taste, and feeling. The odour is that of decaying moist vegetation, the taste that of an infusion of leaves, and the feel as of something clammy, which makes a bath necessary. Not a breath of wind is felt near the ground, although a gust, preliminary to rain, sometimes stirs the upper stratum of foliage. With a lower temperature there would be a dense fog; and our other senses appreciate this fact, although that of sight does not.

We have already spoken of the rich brown humus, and the dark water which flows from it. In the swamp, and to a certain extent also in the river-bottoms, a kind of peat, called pegass, is formed. When dry, it is seen to consist of layers of dead leaves, which break down into an oozy slime. Unlike that black mud so common at the bottom of ponds and ditches everywhere in the open, it is not offensive to the nostrils, but has the characteristics of the true odour of the forest. In fact, both the pegass and the water which flows from it have antiseptic properties, which become of the utmost importance in the economy of tropical nature. For this reason it is brought from long distances into our towns and villages, where it can be compared with the evil-smelling liquid in the neighbouring draining trenches. When dry weather is prolonged, the latter becomes most offensive, while the bush water is always wholesome. This is the proverbial creek water, which if a stranger once tastes, he is bound to fall in love with the country.

The dark water is also agreeable to the trees. When a flood covers the cane and plantain grounds and causes the young shoots to rot, it does not consist of this antiseptic fluid, but of something quite different; a thick muddy water. Possibly the trees of the forest would be unable to endure such a flood, while they seem to revel in the midst of black pools, into which they thrust great mats of fibres of as rich a brown as the water itself. The wallaba (*Eperua falcata*) is so fond of such surroundings that it flourishes in places where there is not a dry spot for miles except on the boles of the trees. These are the wallaba swamps, which often border the wet savannahs.

When the creek emerges from the forest and makes it possible for other than trees to grow up in its channel, it becomes the home of some of our most beautiful plants. The Victoria Regia and other water-lilies flourish to perfection, together with Eichornias, Cabombas, Utricularias, and many more as handsome or delicate. On the other hand, only a few weedy grasses and sedges can flourish in the whitish water, and even these make little headway. A canal of bush water, however, is the scene of an intense struggle for life and mastery between its different occupants.

That this is a provision against the universal bacillus is almost certain. Trees, like animals, are subject to disease, and their secretions are possibly in many cases curative, as they are certainly antiseptic. If they are wounded, the exposed part is quickly covered with a film of gum, tannic acid, and the essential oil peculiar to the species, and in many cases the dressing is effectual. The Indian applies astringent barks to his wounds and ulcers, and the white man compounds a mixture of tannic acid and glycerine for a similar purpose.

The process of breaking up the dead trees by means of termites and a uniform hot and moist atmosphere, results in a fine quality of plant food. Dry-rot can be seen everywhere on our palings and gate-posts; the result is a grey touchwood from which the roots of plants turn away in obvious disgust. On the other hand, the epiphytes in the forest often flourish on the nests of termites, and bind together the clusters of dead leaves and other débris which accumulate in the forks of the trees. Down below, the tree-roots permeate the covering of the ground, and wherever the light penetrates seedlings find everything congenial. The fallen giant of the forest becomes a bank of humus so rich that it has been collected for manure. The antiseptic quality is as conspicuous here as in the water; otherwise perhaps the tropical forest could hardly be possible.

It has been suggested that other secretions besides tannic acid may be protective to trees. We know that bitter and nauseous tastes repel the leaf-eaters and bark-gnawers, but possibly they may do more than this. Have not the Cinchonas, for example, developed quinine for their own protection against malaria? Some old writer has remarked that in every country there are to be found medicines suitable for its peculiar diseases. There may be a germ of truth in this ; the explanation being that the plants are exposed to similar antagonistic influences, against which they have protected themselves.

In confirmation of this we quote the following from Mr. Hart's Report on the Trinidad Botanical Gardens for 1895 :—

"It is not yet the custom for cultivators to avail themselves of the practice of laying all blame in diseases not readily diagnosed to that as yet unknown quantity 'malaria,' and yet it is quite possible that we have just as much right to do so, for it may be found that the diseases of trees and the diseases of animals may be brought about by the same or nearly related organisms ; and, in fact, sufficient proof has already been brought to note to show that so-called malarial diseases are due in the main to specific organisms, although the life-history of the latter may not as yet have been fully sought out and determined ; and also that the vegetable suffers as fully from their attacks as does the animal kingdom."

CHAPTER VI

THE SERVANTS OF THE FOREST

We have already seen that trees and rivers are interdependent upon each other; this is beautifully exemplified in the distribution of seeds. Trees utilise everything that moves, and although they cannot wander about themselves, this is hardly felt to be a disadvantage. Insects, birds, bats, and frugivorous quadrupeds are their servants, and air and water are also bound to give their assistance.

Every tree from its infancy aims to get upward into the sunlight, where only it can produce flowers and ripen fruit. To do this it must rise as quickly as possible, and not waste its energies on side branches until it reaches the little opening which has been its object from the time the seed sprouted. Then the elbowing for room begins, and for some time its whole strength is put forth to occupy the small space and keep back its rivals. When this has been accomplished and the proper season comes round, it at last opens its flowers to the sun and calls together the winged creatures which find a home in the forest. Every effort is now made to attract attention by means of colours and perfumes. Butterflies, bees, and humming-birds come from long distances, as the coloured signals are hung out in the day; moths search at night for the sources of the perfumes wafted upon the night air. The attraction seems to be irresistible, for wherever the trees are they always succeed in achieving their object. Some flowers open only for an hour or two, and in this time must receive the visits of their winged servants. A blaze of fire by day, or a white starlike glitter at night, makes known to the forest world that nectar is to be had, and the winged creatures assemble with a hum or flutter as the case may be. Rarely indeed does a tree fail to attract; if it did so the species would soon be in the background. Thousands of flowers are fertilised and as many seed-vessels or fruits are soon on the way to become the germs of new individuals. For a time this lot of servants retire; they are no longer wanted here, but must look round for other signals.

The fruits ripen; the trees require a new set of helpers, and they are as ready at command as the others. First come the birds, for which are provided succulent pulpy coverings for the seeds, which may be swallowed, and thus carried far away without injury. The bird eats the fruit here and drops the seeds many miles away, possibly in some place where one of them can find room to grow. If they simply fell down to remain underneath the parent, little benefit could result, but by means of these assistants there is at least a chance for a few of them. At night bats fly far and bring in the harder fruits, the coverings of which they gnaw, leaving the seeds to drop anywhere upon the way, or to form a litter about their homes. We have often picked up fruit in our garden that could only have come from trees a mile off, and from the marks of the teeth of these creatures knew at once how they came there. In the forest monkeys also gather nuts, which they scatter in every direction. The monkey-pots (*Lecythideæ*) seem as if they are formed to puzzle the thieves. Enclosed in a great woody capsule, which hangs downward and is covered by a lid, it defies them until the seeds are ripe, when the lid becomes loose. The monkey takes off the cover, but as he does so the nuts fall to the ground, and he is perhaps left with one or two in his paw. The others are lost, for Jacko never seeks them on the damp soil; he helps to scatter them, and has to be content with his toll.

In temperate climes trees make the winds their servants, and this is accomplished all the more easily from the flexibility of their branches and twigs, and even in some cases from the conspicuous trembling motions of the leaves. Clouds of pollen are wafted over the woods to fertilise individuals at a distance, and in such cases the quantity produced is enormous. This is well exemplified in the larch, over which yellow clouds can be seen in early spring. But the wind has not performed all its duties when the fertilising process is over; it has other tasks when the seeds are ripe. What these are can be seen when the ash and sycamore keys are ripe, and also with the winged seeds of the elm. Instead of falling underneath the parent tree, they are wafted to some distance, where perhaps there may be better opportunities for germination. In the tropics there are greater developments of the winged seed-vessels; some are most beautifully fitted for floating to long distances. The "Long John" has its miniature shuttlecocks, and some of the other trees seed appendages that are very highly developed. Then there is the feathered appendage, so conspicuous in the Asclepiadaceæ, and those butterfly-like expansions of some Bignonias, which are as light and membranous as the wings of an insect.

Moisture and the change from wet to dry is a great factor also in the distribution of seeds. Some pods are spirally twisted, and in the change from wet to dry their contents are jerked forth to a distance. But the great servant of the forest is the flood. The creeks and rivers in the tropics are often covered with a scum of nuts, fruits, and pods, round which gather shoals of small fish. These have been carried off from the surface of the ground by the heavy rains, for they all float on water. When the great rainy season comes and the precipitation sometimes amounts to ten inches in one day, the whole forest is intersected by streamlets, and pools form in every hollow, both bearing collections of seeds on their surface. Then the floods rise and spread over large areas, distributing these germs more or less uniformly everywhere, and mixing them together until perhaps a hundred species may be ready in any given spot to await their opportunities. Large numbers are carried into the great rivers and out to sea, where they perhaps find room to grow on some foreign shore, or are thrown up on the beach as far away as the west of Europe.

What an apparent waste of energy! How infinitesimal is the number that will ever find an opening to become trees like their parents! If the whole forest was swept away at once there would not be room for a thousandth part of them. Yet this profusion is undoubtedly of great benefit, for there are enough to feed the birds, beasts, and fishes, and after that some will yet be left over for the weevils.

And what a curious assemblage is floating down the stream? Here are the palm-nuts, the eta covered with scales something like those on pine-cones, the troolie rough as if studded with hob-nails, and the awarra surrounded by orange-coloured pulp. Then there are the yellow hog-plums, round which the fishes swarm, and many another fruit more or less succulent on the outside. As for the pods, the fruits of the Leguminosæ, they are wonderfully varied in size and shape. Great swords, two to three feet long, are contrasted with circular discs the size of a shilling, and these again with little scimitars and great winged pods as large as the hand. They are jumbled together in places where there are back-waters, thrown upon the banks, or left by the flood in heaps and wavy lines. The general result of all this is continual distribution over the forest area, until not a single spot remains without the germs of a little army, only waiting for an opening to enable them to take their part in the battle of life.

Floods not only distribute the seeds, but they make room for them. There is death and destruction here as elsewhere, and it results in new life, progress, and development. Were every tree to live out its term, say from one to two thousand years, progress would be very slow, and once the forest was populated, there would be hardly an opportunity for a single seed. But there are agents at work to prevent such an undesirable result, and the tropical flood comes first. We have seen already what wonderful changes result from the rising of the waters and the formation of dams; all these make openings for new individuals. But there are other agencies at work for the same purpose; friends to the species, enemies to the individual. A time comes in the history of the tree, as in that of the animal, when it is no longer able to carry on the struggle with that ardour it once showed. Its enemies come upon it in force especially if there is a weak point in its armour; *i.e.*, a branch lightly covered which permits a ray of sunlight to fall on the ground. Two, three, or a dozen seeds germinate, and among them perhaps is one of those bush-ropes which twine round and ultimately constrict the trunk in such a way that the flow of sap is partially arrested. This causes a further defoliation, and the great twiner arrives on a level with the roof of the forest. Here it becomes a smotherer and the tree dies, to be removed piecemeal by the termites. Finally nothing is left but the great coil of the bush-rope, showing by its circumference that it once held a giant within its folds.

Like floods, the feathered servants of the forest help on the work of destruction by depositing seeds of strangling wild figs and blood-sucking loranths in the upper forks of the branches. Here they germinate, to ultimately flourish at the expense of their host, which becomes correspondingly weak and sickly as his enemies grow into large bushes. Only the palms are safe against these insidious foes; but they also have their peculiar enemies in the borer beetles, which eat out their very hearts. Unlike the exogens, they have only one bud to each stem; this is most carefully protected, but with all that its enemies often find the weak point, and the great column quickly loses its capital.

Then there are wounds which kill. When a great tree falls it carries destruction in its path. Palms are snapped off and killed at once; exogenous trees get their branches torn away, leaving unsightly wounds and lacerations, which quickly degenerate into ulcers, that corrupt the surrounding bark and wood, until the whole becomes diseased. Nevertheless, there is a great capacity for recovering from a wound, as may be seen in the hollow trunks and half-dead branches of trees everywhere. Every effort is put forth to prevent the spread of the disease, and they often escape with the loss of a limb, rather than of life.

Light is life to the forest, and its absence death. True, some trees can flourish away from the direct rays of the sun, but nevertheless there is always a limit to their endurance. As the shade above becomes more dense they become unhealthy. Scale insects attach themselves to the under surfaces of the leaves, and by their numbers slowly drain away the juices. These are accompanied or followed by black fungoid growths on the upper side, or by other low vegetable parasites which penetrate the leaf itself, and produce grey or yellowish blotches. The tree appears to be calling for more light, which, if it can obtain, will perhaps enable it to throw off the incubus; otherwise its death is only a question of time.

CHAPTER VII

THE FOREST AS A HOME

To ensure the presence of its friends or servants, the forest must provide them with a home. Although so densely packed, the trees themselves are by no means the only occupants of this almost interminable edifice. It is an immense game cover, wherein myriads of animals may lie hidden from man, and yet not only live but enjoy life. Even man himself is a denizen of the tropical forest, and his near allies, the monkeys, make their homes in the trees and feed entirely upon their natural productions. As a rule monkeys have no nests, but curl themselves up in the forks of the branches to sleep. Wandering from one fruit-bearing tree to another, their dwelling-places are continually changed according to the seasons, and the sphere of their wanderings may extend to very long distances. The young require no nest, for they instinctively hold on to the hair or fur of the mother's breast almost immediately after birth.

TANGLED VEGETATION.

The larger quadrupeds have their lairs in the thicket, where they hide during the day; and the smaller, such as those of the Cavy or guinea-pig family, take advantage of the hollows of fallen trees. In the tropics the ground is usually too moist for anything like the burrows of rabbits, which are so common everywhere in the woods of temperate climes. The armadillo, however, is an exception, for, like the mole, it makes tunnels in the sandy elevations.

Birds' nests are universally admired for their beauty and ingenuity of construction. As a rule they are more conspicuous in the English woods than in the South American forest, partly because in the former they are built before the trees put on their dense canopy of foliage, but mainly on account of their more open nature. In the forest of Guiana but few nests can be seen; they are mostly built of dry twigs, and are scarcely distinguishable from the clusters of débris so commonly lodged among the branches. Then they are often hid behind great curtains of bush-ropes, or among the clusters of epiphytes which adorn the branches wherever broken sunlight is allowed to pass. But there are conspicuous exceptions, for the hang-nests (*cassiques*) fix their pendulous sacks, made of long grass, at the extreme points of the branches of some great isolated tree, notably the ceiba, where they appear like monster fruit. Thus protected against snakes and every creature without wings, the bird needs no hiding-place, but appears to be defying its enemies. Sometimes we see a hundred of the nests hung upon a great ceiba, and at others they decorate the crown of a cabbage palm, in both cases far beyond the reach of man, monkeys, or snakes. Parrots make their nests in hollow trees, and the spur-wing of the swamp brings up her young amongst the reeds, from whence she issues in affright on the advent of a stranger. Flying off to a short distance, she flaps her wings and utters loud cries, as if she hoped by these means to draw attention to herself and away from her little ones.

Undoubtedly, the prettiest nests are those of the humming-birds. Often composed of a felt of the feathery appendages of seeds fastened together with spiders' webs, the tiny hemispheres are hung at the end of great leaves of the marantas, which by their smoothness and flexibility prevent the enemies of the bird from approaching. These living gems are undoubtedly among the most interesting of the inhabitants of the forest, and it is delightful to watch them busy at work in the great tubes of the Bignonias or Convolvuli, or perhaps bathing themselves in the film of dew or rain which lodges for a time on the leaves either in the early morning or at other times after a shower.

The most common of all insects in the forest are the ants, and consequently their homes are everywhere. Some, which live in the ground, excavate great chambers, with tunnels reaching to long distances in many directions. From the entrances, well-beaten level roads, perhaps an inch wide, extend and intersect each other, until in its way the little tract of country round the nest resembles a plan of some great city and its environs. Others, from their dislike to the burning rays of the sun, make covered tracks when they have to pass open spots, and as engineering works these tunnels are perfect. However, it is in utilising, rather than in building, that these little creatures excel. They are so numerous that not a branch or hardly a leaf is free from them. You cannot pick a flower without bringing down a few, and if your bateau brushes across a hanging branch hundreds fall into it. Fortunately only a few species are highly venomous; and you get accustomed to the bites of the others.

Many species of ants, which do not nest in the ground, make their hills about the boles of trees, to be safe from the flood; others take advantage of the débris in the forks of the branches, among the roots of epiphytes, in deserted birds' nests, and in hollows of decayed trees. But perhaps the most curious of all is the way they utilise living plants, of which perhaps the trumpet-tree (*Cecropia peltata*) is the most striking. This comes up very plentifully in every clearing, a tall lanky tree with a few branches, at the ends of which are clusters of handsome leaves. The stem is hollow throughout, and the ants perforate the cylinder to find a perfect home ready for occupation. No injury results; but if any benefit is derived from these tenants, which is most probable, it has not yet been discovered. The hollow pseudo-bulbs of certain orchids are utilised in a similar manner, and in such cases there is no doubt that the ants keep off the enemies of the plant. Then there are the swollen nodes of the branches of certain trees or shrubs, which are perforated and hollowed out; and in some Melastomaceæ

TOCOCO FORMICARIA,
With swollen leaf-stalks inhabited by ants.

an enlarged leaf-stalk is treated in the same way. Taken altogether, it is impossible to say where ants cannot find a home as long as the place can be protected from the rain and is above the reach of floods. Far up in the crowns of the palms there are dry chambers between the leaf-stalks, and here they congregate in myriads, while on some low bushes they bring up little heaps of soil to form tiny nests in the axils of the leaves.

The most conspicuous homes in the forest, however, are those of the termites, the work of which we have already had occasion to describe. We cannot see these apparently weak creatures, but their oval masses of cemented mould are on almost every tree, and their covered avenues extend along the branches and down the trunks.

Maribuntas, or tropical wasps, are also very plentiful, and their homes are most beautifully constructed. The most common is pear-shaped, with its outside shell of the appearance and texture of grey cardboard. Some species build a great cylinder two to three feet long; others simply arrange a single layer of cells on the back of a leaf. Perhaps the most interesting, however, which is more common about old buildings than in the forest, is what is called the mud-dauber. It builds a miniature crater of mud, and in it deposits an egg, at the same time, to provide food for the young grub, placing a living but numbed spider in the same hollow. That the numbing effect of this insect is very great we know from personal experience, for its cramping effect spreads from the seat of the sting until partial paralysis is felt.

Spiders and moth larvæ manufacture great webs, which sometimes extend over large areas; other larvæ draw over the leaves of the marantas into folds, which they fasten together with the web until safe quarters are provided. Quite a host of insects simply live under the shelter of great leaves, where they are usually safe from their enemies.

Those animals which take advantage of the cover of the forest and jungle are almost invariably rendered inconspicuous by their protective coloration. The tiger is supposed to have become striped that it might remain unnoticed in a thicket of bamboo or reeds, and the colour of the lion undoubtedly assimilates to that of the desert. The American "cats" are mostly spotted, and these spots undoubtedly resemble the patches of sunlight that fall upon the ground in the bushes where they lie during the day. The puma and several other wild animals of the savannah are of a pale brown, like the lion, but some of these are spotted when young, at which time they are more likely to require protection in their bushy lairs. In the water a dark colour is more protective, and this is provided for the tapir, manatee, and water-hog. With all their beautiful prismatic colours, snakes are almost invisible in the forest, and lizards are equally indistinguishable in the grass. The alligator is brown as the mud on which it lies, the iguana green as the leaves on which it feeds, and the gecko lizard brown like the tree-trunks over which it runs.

CHAPTER VIII

IN THE WATER

We have already spoken of the dark water which fills the tropical rivers and swamps, and its relative the bog water of temperate climes. Its colour is due to the infusion of dead leaves and stems of reeds and grasses, as well as to the washings of tree-trunks and the humus of the forest. It can be imitated by putting a few grass stems into a bottle of rain-water, and exposing the mixture to bright sunlight and air for a few days. The result, as proved by actual experiment in Guiana, is as follows :—

On the first day the water becomes thick and dirty, and on the next it begins to have a putrid smell like that of a noisome ditch. Examination under the miscroscope then proves it to be swarming with bacteria, which revel in the deadly infusion. By the third or fourth day it becomes clearer, and some of the lower infusoria are developed, which appear to be devouring the bacteria. Finally, a few days later the liquid turns brown like the bush water. The bacteria and other low organisms then disappear, and only a few rotifers or bell animalculæ are found, together with mosquito larvæ, which appear to have fed on their predecessors, and thus made the water potable and wholesome.

Many persons have asked what are the uses of mosquitoes and gnats, and here we have a possible explanation. Their business is to clarify the water of our swamps and marshes, not necessarily for man's benefit alone, but for the good of every living thing, both animal and vegetable. Were it not for these so-called pests such places might be the centres of noxious emanations as deadly as the surroundings of the fabled upas-tree. It is well known to the inhabitants of the tropics that the first rains after a long dry season bring sickness, which generally disappears later. Probably this is the result of the swarming of bacteria before they are destroyed by the larvæ; at any rate there is a coincidence which suggests the necessity for fuller investigation. Possibly, even new-comers may at some future time bear with these pests for the sake of the really grand work they perform.

It has always puzzled us to find out the reason why mosquitoes are blood-suckers. Naturally they live and thrive in districts where the larger animals, except those which live in the water, are entirely absent. Hundreds of generations may pass without one of them getting the opportunity for a feed, and certainly they appear to be none the worse on that account. Many insects do not feed at all in their perfect stage; they copulate and die, the males at once, and the females as soon as they have deposited their eggs. That the perfect mosquito is ravenously hungry, every one who has visited its haunts is made painfully aware; it seems to be making up for centuries of starvation. But the why and wherefore are still lost in obscurity, unless we presume that blood-sucking even once in many generations is useful to the species.

In the experiment above noticed particular stress must be laid upon its performance in full sunlight, with the mouth of the vessel open to the air. Light, heat, and air are great factors in decomposition and the development of life; all are required to work together. We cannot take away one without invalidating the result, as may be seen in the comparative cleanliness of an open cesspool to that which is closed by a trap. Everywhere we find the same interdependence of one upon another, which has been so beautifully exemplified by Darwin in the case of the cats, humble bees, and clover.

But the swamp water is not yet purified

altogether when the mosquito larvæ have done their work. They have paved the way for the water-plants, which could not flourish in the noxious infusion that first covered the ground. Wherever the stretch of water is open to the light and still, be it swamp, creek, or river, and also fairly clear, plants will quickly make their appearance and continue the grand work. The great purifiers are those which grow in the water, of which the water ranunculus so common in English ponds is a fine example. In Guiana we have the Cabomba, several species of Utricularia, an Elodia similar to the American water-weed which chokes the English canals, and several others, all of which require the water to be clear, however strong an infusion it may be. These spread very quickly, and although looked upon as pests to be cleared away at intervals to prevent the canal being choked, they undoubtedly aid in the grand work of purification.

But we must not forget the confervæ which are so common in pools everywhere. They are almost absent from the bush water of Guiana, but are plentiful in the drainage trenches, where they do their best to ward off disease and death. The ordinary observer looks upon these beautiful globes and cylinders, which grow so densely in stagnant water, as something nasty—a horrible green slime. He takes it out at the end of his stick, sees it collapse into a noisome mass, and thinks perhaps that it is something to be got rid of at any cost. Yet it is doing a grand work—a work which, in the absence of mosquitoes and gnats, can be accomplished by nothing else. Even the brown slime which remains on the mud after the drying up of the water is largely made up of those beautiful organisms, the diatoms, which are also purifiers, and pave the way for higher plants.

And what shall we say of the scums? The horse-pond, once found in almost every English village, is often covered with a green film, which is also, like the shiny confervæ, looked upon with disgust. Yet here is an organism, the duck-weed, beautifully fitted for the conditions under which it grows; in fact, the *Lemna triscula* is quite an elegant little plant. It is now some thirty years ago since we were led by an article in *Science Gossip* to examine the duck-weeds, and the first sight was almost a revelation. No longer were they something nasty, to be looked upon as a pollution of the water, but organisms, which, although simple, were worthy of the greatest admiration.

When we come to the tropics we find something more beautiful than the duck-weeds. Floating on the brown water of the canals is a film which is also looked down upon as a pollution or scum. Varying in tint from green to almost crimson, it is made up of myriads of delicate plants of the Azolla, as graceful and elegant in its branchings as some mosses. No doubt this is the most handsome of the floating weeds, but the Salvinia is quite as interesting. Like a magnified duck-weed, it spreads very quickly, and its aquatic roots, with their shaggy coverings, apparently gather large quantities of vegetable matter from the water, for they are always brown with it.

In a small way these tiny plants perform a similar work to that of the great Victoria Regia. Between them come the pretty Pistia with yellow-green rosettes, the Eichornia with delicate lilac flowers as pretty as those of an orchid, and a number of others, including the unique water-fern, *Ceratopteris thalictroides.* This last will puzzle a stranger for a long time, as in its early stages it resembles a floating lettuce more than any other kind of plant.

In temperate climes more especially there are other water-purifiers, such as the Charas, which take up inorganic matter, and the Ruppia, which assists in the purification of brackish water.

The general result of this combination of factors, all of which are continually at work, is that each is controlled by every other, and the end of the whole is to make the earth habitable. We need not look far to find out what would happen in their absence; our closed sewers and their pollution of the wells bring the case home to every thinking person. A ditch without water or grass is almost invariably offensive during the time when it is lined with damp mud and before it becomes dry. A swamp, again, when covered with vegetation gives forth no noxious gases unless disturbed, or rather they are not appreciable probably because they are taken up by the plants as quickly as they are generated. But stir it up or destroy the plants and the result is immediately appreciable.

Running water has comparatively few organisms; they can hardly exist in the swift-flowing river. Here in Guiana, however, we have a family of plants which not only stand against the currents, but actually grow on the boulders which produce the rapids of our great rivers. Anchored by discs which act like the suckers of some animals, the flexible leaves of the Podostemaceæ fill the little pools and back-waters in the midst of the rushing torrents. In such situations they can do little to purify the water, but they feed great fish, and these fish in turn become a prey to the skilled Indian archer.

We are inclined to think of running streams as eminently pure in comparison with still waters, but such is by no means always the case. A stinking pool may be regenerated by means of nature's purifiers, but the swift and mighty river when once polluted only loses its noxious properties by mingling with the sea. Here other factors come into play which we must leave for further investigation, as they hardly belong to our subject.

CHAPTER IX

THE FIGHT WITH FIRE AND AXE

MAN helps the forest with one hand and destroys it with another. The Indian makes a small clearing. which he abandons in a year or two. He thus makes room for new individuals, who quickly take possession, so that in a short time it is indistinguishable from its surroundings. Larger denudations take longer to recover, but ultimately the result is the same; once abandoned by man, the Guiana plantation reverts again to forest in about ten years.

Probably the greatest step ever made by man in his progress towards civilisation was the kindling of the first fire. Whether this took place in a warm or cold country is doubtful, but the discovery would be certainly more useful in the latter. By its means he probably overcame the forest as the backwoodsman of North America has been doing during the last century. A child has to learn that fire is something to be carefully handled, and man is only an infant as yet

TIMBER TREES IN THE GUIANA FOREST.

in the great pine-woods. The ashes of a camp-fire, or a match thrown away carelessly, may set up a conflagration that no power can stop until the broad river checks its progress. Villages and small towns are swept away, and the inhabitants fly for their lives to the nearest stream, followed or accompanied by a host of wild creatures. Behind, it leaves an unsightly black desert, absolutely lifeless, and decades will pass before its former covering can be again renewed. Even the seeds which lie upon the ground are destroyed, so that the new growth, if it ever again covers the ground, is formed of soft-wooded trees comparatively useless to man. The work of ages has been undone, and must be commenced again from the very beginning.

The tropical forest cannot be set on fire. When the Indian makes his clearing the trees must lie for several months before they can be burnt. They kindle easily enough then, and create a furnace-like heat amidst the living walls which stand up on every side. Yet, beyond a little charring to the leaves, the trees suffer no harm. Instead of being a danger in case of fire, the trees of the tropics afford one of the best screens against it. A wooden house when burning may set fire to another across the open street, but its next neighbour may escape through having a mass of vegetation interposed.

The woodcutter of Guiana, in chopping down trees, leaves the stump three or four feet above the ground. This is often charred all over, and yet it sprouts again when the heavy rains fall. It does not appear, however, that exogenous trees here have the same power of sprouting from the roots as is conspicuous among some of their cousins in Northern climes. For ages all their efforts have been directed to development at the top, and when destroyed to the ground they cannot recover.

Although forest fires are unknown, the swamp is often burnt after a drought. The water disappears, the reeds become brown, and the pegass soil turns from an oozy slime to an elastic bed, which sinks under foot with a crunching sound at every step. At such times every part is highly inflammable; the dry reeds kindle with a spark, and the pegass burns like peat. Flames rise up at first, accompanied by reports like pistol-shots; in fact, it might be compared to the shooting in some of the English woods on the first of September. This conflagration is quickly over, but the pegass glows like a furnace for several days, giving off an unbearable heat. Yet with all that the giant razor-grass (*Scleria*) is not killed; with the rains it again comes to the front.

Man makes a clearing in the tropical forest;

it may be two or three acres or it may be as many hundred. In doing this he is carrying on a struggle where only incessant effort on his part can keep off the enemy. This fight can be best illustrated by giving the story of a coffee plantation, one of many in the same district which have gone through similar vicissitudes.

A century ago this was one of those which helped to raise the shipments of Demerara coffee to millions of pounds per annum. Then the district in which it is situated was flourishing, and every plantation had its one to two hundred acres of this beautiful shrub. The forest was kept at bay, but it existed behind, and gave continual work to the slaves to prevent its encroaching upon the coffee-fields. Labour was cheap, and year after year passed, to see the cultivation extended and the forest behind driven farther back. The thrifty planter could look on with pleasure when the white jasmine-like blossoms appeared, and later, when the bushes were covered with their red cherries, rejoice in the expected produce.

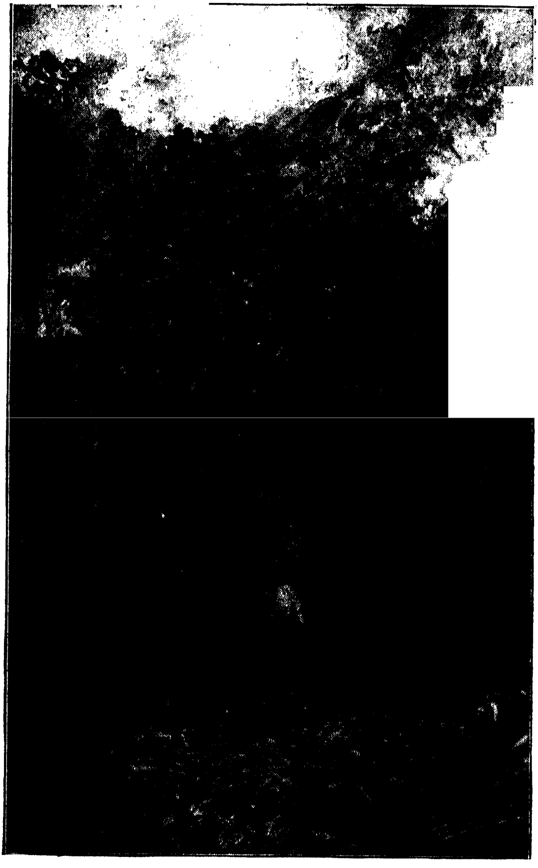
But a time came when the price of coffee was so much reduced that it was on a level with sugar, the produce of which per acre is very much greater. Then came so great a demand for labour on the new sugar plantations that those in coffee were neglected, and at once the forest began to encroach. The estate in question was at last abandoned, for when there were no pickers the fruit became valueless. Before this had taken place, however, the want of labour for weeding had allowed the preliminary skirmishers of the forest to come to the front. Strong hardy grasses grew up between the bushes, giving these openings at first the appearance of a rice-field; their couch-like rhizomes gradually stole the plant food from their larger neighbours. The unpruned coffee did its best to smother this invading host, but could do little. Then came another skirmishing party, the loranths, the seeds of which were dropped by birds. These parasites quickly began to suck the life-blood of the bushes until they dwindled and gave less shade; then the grass grew stronger than ever. A smothering host, the Philodendrums, like giant ivies, came next, and soon their great leaves were ornamenting the bushes and shutting out some of their light. The more deadly wild figs also began to appear, to hasten on the work of destruction, which could easily be recognised as in progress by the host of termites which now came from afar to bury the corpses.

These preliminary skirmishers prepared the way for the main body, the trees, some of

COFFEE PLANTATION OVERRUN BY FOREST.

which, such as the Vismias, had already risen, notwithstanding the attempts of the grasses to choke them. What with these and the figs, in four or five years a second-growth forest had taken the place of the once well-kept estate, and in double that time a stranger might have said it had never been under cultivation. The expert, however, could recognise the fact that a clearing had once existed, and perhaps find here and there a survivor which had by chance escaped.

Some thirty or forty years ago the plantation, or rather piece of densely wooded land, came into the hands of a woodcutter who found it conveniently situated for his business. The soft-wooded trees were useless for timber, but as common firewood, they could be utilised. Gradually a clearance was made, and the owner, taking advantage of this, again began to plant coffee and also cacao. About a hundred acres were thus put under cultivation, and it looked as if a fine estate would once more exist. But unfortunately, before the work was completed, he died, and in the end the place was sold to a man who thought it could be made into a fine homestead for himself and family. But by this time the vanguard of the forest had again appeared, and the young plantations, save for a short distance from the dwelling-house, was



LIBERIAN COFFEE-TREE OPENED OUT.

smothered with weeds. With his small means, however, he set to work, and did a little to prevent things becoming worse, but could not accomplish any real good. Strong hands were wanted, and without sufficient capital they could not be obtained. From four or five acres of fruit-trees and plantains he got enough to make a bare living. But things became worse instead of better, with the result that about two years ago the estate was again sold.

The new owner is now hard at work trying to once more drive back the forest. Hundreds of cacao-trees were hidden among the second-growth, their long, lanky stems obviously suffering for the want of light. As for the coffee, most of it was killed, but here and there a survivor could be found, one of which we have photographed. It is of the Liberian species, which can endure shade better than the ordinary kind, but naturally has been unable to flower and fruit under such adverse circumstances. To suddenly expose these weak creatures to the direct sunlight would mean death, and consequently they have to be opened out little by little, the work requiring the greatest discrimination. However, the struggle with the forest has again commenced, and its conquest is only a matter of labour and time.

Is it any wonder that in the face of such a foe the tropical man often gives way? The plants he cultivates are not the natural denizens of the country; the latter will decidedly get the mastery if left alone. They have been trained in this particular field, and can more easily repel their enemies than the poor objects of man's care and attention. As aliens, the natives are at enmity with them from the very beginning; the parasol ants denude them of their leaves, scale insects suck their juices, loranths bleed them, fungi penetrate their very tissues, and around them is a smothering host of a hundred species triply armed. Without outside help they cannot contend with such an array of enemies, and only man can help them.

CHAPTER X

TREES NECESSARY TO CITIES

THE farmer, the planter, and the forester are all straining to overcome nature—to eliminate the struggle for life between different species and different individuals. Under natural conditions every plant has its opportunities, and the balance is evenly adjusted; man attempts to undo all this, to grow what he wishes and destroy what he considers objectionable. This he can do only by continual labour and care; the weeds are stronger than his protégés, and it is only by his taking sides with the latter that they can exist at all. Possibly if left to themselves they would be all destroyed; certainly they would either recover some of their lost powers or be swept out of existence. For good or evil this must necessarily be the case, and the question occurs to us whether it would not be better for the whole realm of nature if civilised man were eliminated.

However, even here he has excuses. Other animals destroy as much as lies in their power: why should he not do the same? There is no reason for his giving up the fight when the very grasses and trees do their best to overcome their neighbours; like them, he is bound to go forward or die, and the tropical man who despairs or lets things take their course is by no means worthy of respect. Selfishness rules all nature, and man is no exception. His care for plants and animals is taken from no feeling of benevolence, but simply because they are useful to him and serve his purposes. Otherwise, the animals are vermin and the plants weeds, to be driven from the face of the earth as quickly as possible.

Fortunately for the trees of the wood and forest, they are useful, and the more we study them the more we see how much depends upon them. Still, from the naturalist's point of view we cannot help regretting that so much of the loveliness of nature is disfigured for man's benefit, and that woods and forests have been destroyed purposely or carelessly for want of appreciation of their usefulness. Some have gone so far as to say that woods and game covers are things to be got rid of as quickly as possible, to give place to meadows and cornfields, entirely ignoring the fact that much of the woodland would not pay for cultivation.

But even if it were otherwise, we must plead for their retention, not only on æsthetic grounds, but also for the reason that they are highly beneficial even from the utilitarian's point of view.

The modern English farmer has taken to well-trimmed hedges, and in many cases has entirely destroyed the trees which once afforded grateful shade to the cattle. Of course they checked the luxuriance of the grass beneath, and by their root-extensions sapped the ground for some distance, but, after all, these drawbacks were greatly counterbalanced by their value as timber. Besides this, they undoubtedly helped to prevent the disastrous effects of long droughts by conserving moisture in their neighbourhood, and often provided a little sweet grass when the open pasture was arid and produced nothing but dry bents. Again, the coppices and woods of England afford cover for springs, which without them would in some cases be intermittent, to the great disadvantage of large stretches of country.

How could we part with our English woods! Even when the selfishness of their owners prevent their being open to the people, there are generally roads and pleasant drives through them. Then they form hiding-places and homes for birds, which add so much to the feeling of satisfaction produced upon the lover of nature. This reminds us that the chorus of song which rises in the morning from an English wood or its neighbourhood is not heard in the tropics. The voices of the birds are, it is true, not wanting altogether, but they are mostly harsh and peculiar rather than sweet and trilling. Without trees nature would be almost dumb, and that dull life so common in large cities would largely prevail.

Great towns may be necessities of civilisation, but they are undoubtedly deficient in much that conduces to the pleasure of life. What can be so grateful to the denizens of the streets and lanes as a day in the fields or woods? This love of nature is beginning to be felt more and more every day, and attempts are being made to plant trees beside the streets. Unfortunately, however, few cities have avenues sufficiently broad to permit this. Once they were surrounded by walls, and within these enclosures the houses were packed as close as possible; now we want parks, gardens, and boulevards, so that nature may again be introduced.

How beautiful a town may be made by trees can be seen in the case of the capital of British Guiana. Built upon what was once a mud-flat, and naturally wanting in every element of the picturesque, it is nevertheless redeemed from sordidness by vegetation. From a tower, the observer, looking away from the river, sees an open forest in which the houses are embosomed. Magnificent palms rise above the level of the roofs, and the wide streets are lined with avenues of trees which are not only grateful to the eyes, but undoubtedly useful from a sanitary point of view.

To produce such a result in the cities of Europe is, however, in most cases impossible, and even in those of the United States it is becoming more difficult every day. With the craze for high buildings, the streets are virtually becoming narrower and narrower, until soon they will be little better than the lanes and alleys of old towns. For the streets, however broad, will not appear so when twenty-story buildings are erected on either side. Were such a thing general, not only trees would be impossible, but gardens as well for light is absolutely necessary to their welfare. The advocates of tree-planting in cities will therefore have to agitate for new regulations as to the height of buildings and width of streets before much good can be done.

That this new movement is a backward one can easily be understood. If light is necessary to the growth of a tree, it is equally indispensable for man. For many years past there has been an agitation against slums, which are little better than sinks where contaminated air can be retained. Houses forty feet high with an alley of twelve feet differ little from streets five times as broad with buildings like those of Chicago and New York. The ideal street must be equal in width to the combined height of the two rows of buildings on either side, and even then, in Europe and North America, the side facing the north will be generally dull. To have healthy and beautiful cities, streets cannot be too wide; even the broadest at present in existence is unsuitable for such high buildings as are to be seen in some of them. And yet we have been spending money in every old town to abolish an element of danger to health and life, only to see the same element reproduced on a larger scale.

Heath, in "Our Woodland Trees," asks:—"Why cannot it be recognised that townspeople would immensely gain both in health and in pocket by an extensive adoption of town tree-planting? Why will not people see that much of what they spend in poor-rates might be saved by the introduction of more trees into towns? Trees are sanitary agents, more efficient and more persistent than public officers of health. They absorb the noxious compound known as carbonic acid gas, reduce it to its simple and healthful elements of carbon by making it contribute to their substance, and hence to their life, vigour, and beauty, and give back pure oxygen—our vital air—for the healthfulness and pleasure of mankind."

The love of nature is instinctive in the child, and there is something elevating in a country life. Poets have retired to out-of-the-way places where they could be free from the distractions of the city, and in doing so they were following this instinct. The popularity of flowers is becoming more and more evident every day; the poorest cottager tries to get a little posy of wild-flowers whenever they can be obtained. And how very beautiful some of the English flowers are can only be understood by persons returning home from the tropics after a long absence. Little children from other climes want to get out of the railway-carriage to pick violets and primroses when they see them for the first time. Even the neglected daisy is to them a most charming object; in fact, they revel in the delicate beauty of English wild-flowers, after seeing only the more brilliant and gaudy blossoms of the tropics. Without the woods and the hedges, with their banks, even the primrose would be scarce, and many another floral gem might become extinct.

Let us bring trees into our cities, and lay out parks and gardens, but at the same time we must not abolish our woodlands. Whatever may be said of the beauty and symmetry of order and design in the arranging of trees and flower-beds, the apparent confusion of a thicket nevertheless has a character of its own, which we cannot afford to lose. Then there is something about the natural wood which cannot be imitated, and which has taken in some cases centuries to produce. Its wild-flowers differ from those of the newer plantation, and it has the charm of greater variety. If it is necessary to preserve historical monuments, is it not also equally desirable to spare some old bits of woodland?

A great deal has been said about the English game laws; they have been stigmatised as barbarous, and a disgrace to the country that upholds them. They are certainly objectionable in many respects, but they have done a great deal of good by preserving coverts which otherwise might have been destroyed. Their object, which is virtually subservient to mere wanton destruction, is undoubtedly immoral, but, like many other apparently evil things, they have an element of good in them. That such is the case is proved by the fact that people in the United States are beginning to cry out for something similar, and already one or two game reservations have been set aside. It has been suggested that there should be tracts of forest kept intact in every State, and that if such were done the benefit to the true sportsman would be incalculable. In these places no one would be allowed to hunt at any time; they would be homes and shelters for the wild game that now range the surrounding country in fear of their lives, where the beasts and birds might bring up their young in peace. Wardens might be appointed to prevent poaching and incendiarism, and penal laws be enacted to give them the necessary powers to this end. Such arrangements would not interfere really with hunting and shooting; on the contrary, they would conduce to the elevation of sport, and prevent species from being exterminated, which is fast taking place in many districts. No care would be taken to prevent the game wandering about everywhere, and shooting could be carried on in the neighbourhood for ever, when there was no possibility of destroying the real harbouring-places. How much better would this be than the English system! There would be at least one safe place for the hunted animal; a city of refuge where no one could interfere with him. Again, battue-shooting would have to be abolished, a desideratum to be ardently wished by every one but he who thinks his capacities and powers are best exhibited by the number he kills in a given time.

To the botanist and zoologist the advantage of a piece of woodland in the neighbourhood of a town is patent. Although he may not be admitted within the preserve, there will always be places on the edge where rare plants can be found and where animal life can be observed. Their interests are different to those of the sportsman, but the bit of undisturbed woodland is acceptable to all.

Wherever there are great cities, with schools and colleges, a piece of coppice at least should be preserved by the authorities for the benefit of the public, under certain stringent rules. This might in many cases be secluded within a park, and be only open to students or naturalists, under strict regulations as to interference with the inhabitants.

That such preserves would be a great boon there can be no doubt. Naturalists have continually to deplore the want of opportunities for studying nature apart from man's interference, and the increasing scarcity of animal life. Charles Waterton attempted something of the sort by building a wall round a part of his estate at Walton Hall, Yorkshire, and this harbour became the resort of many rare birds. The study of herbaria and cases of stuffed skins is no longer satisfactory; the naturalist must go to nature, and the student must have his field of investigation brought nearer to him.

More and more every day we see that, if man's interference is not to produce disastrous results to himself, he must study Nature as a whole. The destruction of insectivorous birds, and even what is commonly called vermin, must be checked in some way; that the ordinary game preserve is not the best way is quite certain. The balance of life, as it is naturally preserved in a country, is the result of the interaction of one factor on another in such a way that every living thing is a link in the chain, which cannot be broken without serious results. The study of zoology in a museum or collection of caged animals, or the study of botany from herbaria, &c., in gardens, can never tell us what ought best to be done. The naturalist must go to the field and forest, the stream and lake, and see how plants and animals live, and how they are prevented from entirely destroying each other.

In the tropical forest, apart from man's interference, the balance of life is evenly kept for ages. Now and again, mainly from a greater or lesser rainfall, the increase of one or more species may be checked or accelerated, but in a number of years these oscillations generally tend to become even. For ages every living thing has learned to accommodate itself to such changes, and although some may languish for a time, and thus give greater scope to others, they again recover their place when different conditions prevail. Cultivation of plants and domestication of animals tend to render them less able to bear the vicissitudes of the seasons; in fact, man often preserves variations which would be extinguished if left alone. Natural selection must necessarily result in the survival of the strongest, but artificial selection, with our present imperfect knowledge, often preserves the weak.

This is an age of specialists, and, possibly owing to the attention paid to one section of nature, its dependence on others may be overlooked. A year or two ago we looked on bacteria as pests; now some of them are found to have a powerful influence on the welfare of plants, by their bringing nitrogen into a condition by which it can be assimilated by the roots. This discovery, which could only be made by experiments on the living, shows the necessity for even the specialist to work in the field as well as the laboratory. The student must go to nature, and the nearer our fields and woods are brought to him the easier will this be done.

CHAPTER XI

THE STUDY OF NATURE

VEGETATION and water, forest and stream, are mighty powers in the world, and in fact they virtually go to make the earth lovely. That the study of their influence should therefore be of the highest importance is obvious. When we speak of the beauties of nature, its charms and attractions, we mean the cataract, the river, the lake, and the trees and plants which adorn them.

Writers of a century ago, or even later, have looked upon the study of nature with contempt as something petty, and only fit for small minds. "The proper study of mankind is man" has been quoted over and over again, as if man stood apart as a being so widely different from all others that he need take no interest in anything beyond his own immediate surroundings. There was some reason for this when the virtuoso or closet naturalist was the type, but even then there were such men as Gilbert White and Charles

Waterton, to save the mere collector from universal condemnation. More and more every day, especially since the light which has been thrown upon nature by Darwin, it is beginning to be felt that the old question, *Cui bono?* is beginning to be answered. The "good in everything" is no longer hidden altogether, whatever the pessimist may say.

The sordid mind is too apt to ask whether the study of nature will be profitable to him individually; whether it will protect him from losses or increase his personal comfort. Then he wants immediate results, which cannot always be forthcoming. The realm of nature is so vast and so intricate, that even now we are but groping in the dark, and picking up little bits of knowledge here and there. When the primitive man looked upon the forest as an obstruction—something to be got rid of at any cost—he knew nothing of its importance to his own welfare. It was an enemy to be attacked with the same weapon that he used against his animal and human foes, the stone axe. Yet, as we have shown, the forest was even then of great importance, for without it his hunting-ground would have soon become useless, and probably he himself would have died out.

When the Indian of the forest, or the peasant from the country, walks through the streets of a town, we are inclined to look upon him as something lower than ourselves. But when, on the contrary, we desire his services in passing through the forest or wood, we find out his value. He is in a way a naturalist. He can tell us of the trees, the birds, and the beasts which live in his domain; can show us their haunts and see them when our untrained eyes are unable to pierce the jungle. Children in the country are also incipient naturalists, and although many of their observations are made with a view to wanton destruction, the fact remains that they are keen investigators. Down till lately this receptivity has not been considered; the schoolmaster has confined himself to his set of rooms, instead of giving natural history lessons out-of-doors. Some of our most pleasant memories are connected with outings, where, with a friend who knew more than ourselves, we took our first peeps into the world of forest and stream. Some thirty or forty years ago the microscope was to a certain extent brought into popularity, and the aquarium was more popular than at present; many a pleasant hour was then spent in collecting objects for the former, and living creatures for the latter. But the fashion appears to have gone out; it was only a fad, which gave way before others, not perhaps so useful, and certainly not as interesting. Some of us who have been connected with Field Clubs and Colleges, where the Professors of Botany take their classes into the woods and gardens, remember how enjoyable these excursions were, and how deep was their impression. They were not only a relief from the dulness of indoor study, but practically illustrated what we had been getting up in a much more superficial manner from books.

The study of nature teaches us to use our senses to the best advantage. We note resemblances between different things and observe the dependence of one upon another. This helps us to think, and to use our reasoning faculties to good purpose—the whole end and aim of true education. As investigation proceeds from general to particular we find that hasty conclusions are not likely to be very accurate; this leads to closer observation and that respect for adverse opinion which is so desirable. For, after all, it does not follow that our deductions from facts are even near the truth; the facts are right, but everything beyond is at least open to question. The more ignorant a man is, the more stubborn and opinionated he will be; what we find most wanting in the world is the true sceptical spirit which considers that most of the great disputes of past times were uncalled for, because neither side had sufficient ground for its opinion.

A great question at the present day is that which is concerned with the difficulty of developing both mind and body, without giving undue prominence to either. Sports of various kinds have come to the front during the last century; they are absolutely necessary to the youth of our great cities. But it is doubtful whether the out-of-door life of the country, for which they are a substitute, was not better in every way. It was something more than animalism pure and simple. Labour in the fields was undoubtedly healthy, and there was plenty of room for thought in the continual efforts of the agriculturist to overcome the enemies to his crops. To the man of the city who wants a hobby, nothing is so useful as the study of some branch of Natural History. He wants something that will take him out into the country—something to give him an interest in his excursions. Without such an incentive his country rambles have little interest; his total ignorance leads him to spend most of his holidays in rural inns. Instead of carrying back memories to enlighten his dull routine of labour, he often suffers for a few days after his return from the effects of his excesses. The naturalist, on the contrary, has only pleasant memories of the forest and stream, the open field and mountain; he brings with him material for study, and looks forward with pleasure to the next opportunity.

The naturalist sees things that are practically invisible to others. A factory to other than the technical expert is little more than a jumble of wheels, and the forest and wood are mere jungles to the ordinary traveller. A confused mass of vegetation lies before him, pleasant no doubt as a shelter from the burning sun, but otherwise quite without interest. The artist is pleased with the delicate shades of green in spring or the glorious tints of autumn, and is perhaps struck by the picturesque grouping of a clump of trees or the grandeur of some forest giant. The sportsman, again, sees what he looks for, the evidences of the presence of bird and beast, on which he means, if possible, to bring destruction. Each has eyes for some particular thing, but the true naturalist observes everything, and finds a pleasure in peeping at, without disturbing, the gambols of the wild creatures in their homes. On every excursion he sees something new, for, what with the change of seasons and the continual progression of every living thing, the scene is ever changing.

Although the naturalist sees so much more than other men, it does not tend to make him exult in his knowledge. On the contrary, he knows how many problems have continually been suggested by his observations, and how few of them he can solve. He who thinks that a theory is something cut and dried, into which the parts of nature can be fitted like the pieces of a picture-puzzle, is very much mistaken. No one knows so well the use of a theory and at the same time its insufficiency. Without it perhaps we might have a confused assemblage of facts—with it these facts are arranged in some kind of order. Better this than nothing, but one theory displaces another as the field of study becomes wider, and as we get upon higher platforms. The superseded theory has enabled us to move onward; but we need not despise it because it is no longer required. Mightier tasks remain yet to be accomplished than any hitherto performed, and some of these we have indicated in another chapter as the future work of the forester.

One good result of the study of nature is the total elimination of that fear, dread, or horror of certain creatures, common to women, and not absent even from man. Little children are often entirely free from this feeling until it has been instilled into them by older persons. Snakes, toads, beetles, spiders, and larvæ are detested by many persons, entirely apart from any question of their power to do injury. Then there is that superstitious dread of owls, goatsuckers, and ravens, as if their voices had anything to do with the fate of human beings. The "voices of the night" in the forest are peculiarly interesting to the naturalist, as they are often so difficult to trace. All around him are creatures at work, and he often has to remain unsatisfied as to the identity of a particular animal the voice of which he frequently hears. In many cases the Indian can tell him, but there are sounds in the Guiana forest which even the red man does not understand. He huddles himself in his hammock and attributes the cry to a mythological wild man of the woods called the Didi, which no one can see without danger to life. This creature is still unknown; probably it is some night-bird as yet not identified by the ornithologist.

The naturalist who camps in the forest for the first time is filled with a feeling of awe and wonder. Save for the continual hum of insect life, which soon becomes unnoticeable from its monotony, there is nothing to be heard unless one of the night-birds flies across. Then he is startled by a cry like "Who are you?" "Whip poor Will," or that other weird call which Waterton compared to the scream of some murdered victim. They pass over and go on their ways, and he strains his ears to find if there are any other "voices of the night." Now and again comes a sound like that of people talking, and he asks his guide whether there is another camp near by. No, for twenty miles there is not a single human being; what he hears is only a tree-frog. Yet, at intervals, he cannot help thinking that it must be some party like his, for the voices, although apparently distant, are so distinctly human. To the negro some of these sounds are omens, and it is related of a plantain-stealer that he dropped his booty on being challenged by a goatsucker.

The first night of camping in the forest is often a sleepless one. An ignorant person might be afraid of jaguars and poisonous snakes, but the naturalist knows that these creatures will not come near the camp-fire. He listens intently for every sound, and towards morning is able to count the great drops of dew which fall from the canopy above upon his tarpaulin or on the ground with hollow thuds. If he has camped on the bank of a creek there will now and then be the splash of some fish as it jumps almost out of the water to reach one of the winged insects hovering just above the surface.

An interesting study for the sleepless naturalist is the camp-fire. Attracted by the light, many a rare beetle or moth comes blundering along, to be frizzled up by the flame. Missing its object, it may fall into the hammock, and, if a beetle, make its presence known by crawling between your body and the netting. It is then that you understand what strong creatures they are, considering their size; the weight of your body is no hindrance to their progress. Now and again, also, a candle-fly comes sailing along, its continuous light glowing like a will-o'-the-wisp among the bushes.

In the swampy forests and on the savannahs, the most strange experience is the sudden firing of a cannon, as it were, and when this is heard at night it is indeed startling. You know that, save a few wild Indians, there are no inhabitants for a long distance, and that the boom cannot be that of a cannon. No one has been able to find out the cause, either in Guiana or in the Delta of the Ganges, where a similar noise has been heard.

To the superstitious these nocturnal sounds are frightful; to the naturalist they are certainly awe-inspiring, yet at the same time suggestive of problems to be solved. In fact, the forest is, above all other places, full of mystery; the ancients peopled it with Dryads, and our fairy mythology teems with stories of the marvellous, the scenes of which are laid within it. These stories belong to an age when primitive man found the dense wood his greatest enemy, when it cut him off from both friend and foe. He lived, perhaps, on the bank of a river, and knew hardly anything of what lay beyond the area of his hunting-ground. The unknown was mysterious, and a field for imaginings of the wildest kinds.

As man opened roads through the forest, and in many cases destroyed it by fire, he began to get over his superstitious feelings, and to treat it with contempt. So far did this go, that it was looked upon as only something to be destroyed as soon as possible—a hindrance to the development of civilisation. But a new feeling is now growing up, and the operations of nature are being carefully watched by naturalists in every country. The close dependence of one living thing on another, and the danger of interference with any single species, is now being understood. The destruction of a supposed enemy to the corn-field, garden, or orchard often leads to disasters that we, in our ignorance, could not anticipate.

That there should be a pleasure in investigating nature, apart from its manifest utility, is a very important thing. The scientific investigator often makes discoveries which are apparently useless and, in his state of ignorance, utterly incomprehensible; yet some future generation may find such discoveries to be links in a chain which, when completed, becomes of the highest importance to man's welfare.

It is noticeable that man's progress largely depends upon his faculties for investigating and overcoming difficulties. The forest was first a mystery; then it became more known, and something to be fought with. The first instinct developed in a child is that which leads to destruction with a view to find out something. When he breaks a toy to see how it works, he is in a way investigating cause and effect. As he grows older he experiences a delight in examining some intricate piece of machinery, and often attempts to make models to show his ingenuity. Even negro boys in the West Indies bring their bits of mechanism to Industrial Exhibitions.

If the study of such things is interesting, how much more so must be that vast assemblage of forces which make up the realm of nature! The intricacy of its "wheels within wheels" is so great that we can never hope to understand every part. This adds to the interest, for, after all, the pleasure of a full attainment of certain ends is marred by a feeling similar to that of Alexander the Great, when he wept because he could find no other nations to conquer. More and more every day we are beginning to see that the end and aim of life is action; matter without force is inert, and to attain a position where nothing more could be learned or expected would certainly not be desirable.

CHAPTER XII

THE GREAT FOREST REGIONS

Trees give a character to the countries in which they grow, and attempts have been made to divide the world into regions according to the predominance of certain species. The four great regions, as laid out by Schouw, are, first, the zone of coniferous woods (pines and firs), which extends over the northern parts of the three continents; second, that of the catkin-bearing trees (oaks, beeches, &c.), which covers the remainder of the northern ex-tropical region; third, that of the multiform or mixed forests, which includes the whole of the tropics; and, finally, that of the rigid-leaved woods (eucalyptus, myrtles, &c.), confined to a part of South Africa and two-thirds of Australia. These zones are well defined and can hardly be mistaken, but when we attempt further division, segregation becomes more difficult. Schouw has enumerated eighteen provinces, distinguished by the predominance of certain

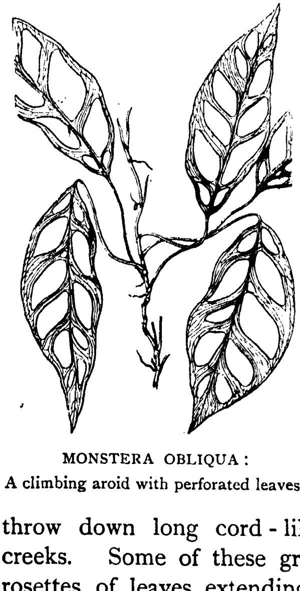
GROUP OF PALMS WITH PHILODENDRUMS.

peculiar forms which we have not room to give in detail. We may mention, however, that tropical South America is in the kingdom of Cacti, Piperaceæ, and Melastomaceæ, which contains the provinces of (*a*) Ferns and Orchids and (*b*) Palms. These forms are undoubtedly prevalent over this region, but if we judge by the drawings of Appun, some of which we reproduce; and the impression of the vegetation on a stranger, the Scitamineæ and Aroideæ, of which the banana and moccamocca are types, come to the front as often as tree-ferns and palms. The fact is, the tropics have a truly multiform vegetation, and if one form of tree predominates, it is the Leguminosæ, or bean family. The physiognomy of

A PHILODENDRUM,
Showing its ivy-like habit.

the different genera and species of this order, however, cannot be generalised, and as their crowns are mostly lost in the canopy of foliage, they make no real impression on the observer.

The Aroideæ are decidedly prominent, however, from their immense arrow- or heart-shaped leaves, with here and there a species cut up, as it were, into segments, or looking as if perforated with a lance. Some grow in the water, others climb the trees, while a third class perch up among the branches, from whence they throw down long cord-like roots into the creeks. Some of these great epiphytes have rosettes of leaves extending to ten or twelve feet in diameter with the leaves themselves without their stalks, three or four feet long, and nearly as broad.



MONSTERA OBLIQUA:
A climbing aroid with perforated leaves.

The banana and maranta form is quite as prominent. Growing in clumps or beds, it stands forth to catch the eye of the stranger. Some of the Heliconias have great boat-shaped bracts, which glow with the richest scarlet and crimson; they can best be compared to the beak of the toucan, which each bract closely resembles. Standing in the midst of its immense leaves, the flower-spike forms a most admirable contrast to the shining green foliage and reed-like stems.

PHILODENDRUM IMBE.

As for the orchid form, this is not at all prominent. Like many of the wild-flowers of temperate climes, the lovely orchid rewards those only who have their eyes open, and who use them to advantage. Like the insects which their flowers sometimes resemble, they are hidden from every one but he who knows the forest. We have passed through creeks many times without seeing a single plant, but later, when our eyes were opened as it were, a fine collection has been made in the same place.

PHILODENDRUM PANDURÆFORME.

To divide the great tropical region into districts from the physiognomy of its plants is virtually impossible, and although there are great differences between the floras of tropical America, Asia, and Africa, the general resemblance is also very great. The most rational method of classification appears to be that which considers the watersheds.

We have already seen how dependent the forest is upon the river, and it must necessarily follow that this influence is exemplified in the flora of a country. Where ranges of mountains or high hills divide two great watersheds the vegetation on one side is often quite distinct from that of the other, even apart from climatic differences. The high ground is a great check, while the river and its floods often afford the best means of dispersion, not only to plants, but to man and other animals. The relative abundance of species is certainly determined by many factors, such as temperature, rainfall and air-currents, but watersheds undoubtedly deserve the greatest consideration. By careful observation, even small rivulets may be seen to have their influence on plant distribution, certain species being found at different points on their banks which are rare or absent from other streams not far away.

Streams bring seeds from the mountains, and, as might be expected, Alpine plants are brought down to the plains, where in some cases they flourish and become common. *Circea alpina* is an example. Originally an inhabitant of hilly districts in Germany, it has become plentiful in woods on the lower levels. It has simply followed the streams. On the coast of Chili, also, several Andean plants have been found straying from their natural habitat. In early times man himself often chose the banks of rivers for his home, and the early travellers in South America connected certain tribes with particular rivers, to which they were often confined.

From this point of view, the great watersheds of the world form areas within which there will be resemblances in the fauna and flora. In South America there appear to be three of these, those of the Orinoco, the Amazon, and the Paraná. When, however, we take into account the fact that there is no great range of mountains between these river-systems, and also that some of their branches connect with each other, we see that they form one great watershed, which includes also a number of smaller rivers flowing into the sea. As might be expected, this immense area has a fauna and flora which can hardly be separated or subdivided in the absence of other controlling factors.

On the west of the Andes is a region which has no great river-system and very little forest; there the vegetation is quite distinct and wanting in variety, as compared with that to the east of this great chain of mountains.

In North America there is also a great river-system on the east, that of the Mississippi. Unlike the Amazon or Orinoco, however, its uniformity as a province of the vegetable kingdom is modified by great differences in temperature, as it flows from north to south. But notwithstanding this modifying factor, the area is well defined and its characteristics beautifully exemplified in Professor Sargent's "Report on the Forests of North America," in the atlas of which it stands boldly forth as a region of deciduous trees below the coniferous zone of the north. Its great branch, the Ohio, also has its own subcharacter, which can easily be distinguished by the botanist and forester. On the other side of the Rocky Mountains the forests of California form another distinct province, in which we find the watersheds of the Sacramento and San Joaquin united. Farther to the north is that of the Columbia river in the coniferous region, which may be compared with the eastern watershed of the St. Lawrence, including the great lakes.

In the Old World there are also great watersheds, which affect the character of the vegetation throughout their whole area. The principal of these in Africa are those of the Nile, Niger, Congo, and Zambesi, all of which are in the zone of multiform woods. Asia has the watersheds of the Ganges and Indus, and of several others in Indo-China and China; and Europe has no doubt been affected by the Rhine, Danube, Dnieper, Don, and Volga.

Wherever there are great river-systems in comparatively level valleys, there seeds must necessarily be distributed more widely than over other watersheds where the fall is greater. The Colorado, with its deep gorges called cañons, has very little influence; there are no forests on its banks, and the country through which it flows is little better than a desert. Virtually without water, its system is almost devoid of trees; a desolate region forsaken by man and beast. The river drains mountain districts far away and does little good to the country.

In the tropics, as we have already stated, the forest comes down to the sea-shore, and the ocean becomes a great factor in plant distribution. Some of the seeds are so hardy that they can endure a long immersion in salt water, and are borne across the ocean to form thickets of mangrove and courida on every coast where the temperature will permit. Besides these there are other shrubs, such as *Thespesia populnea* and *Hibiscus tiliaceus*, and even a fern, *Acrostichum aureum*, which grow on both sides of the great oceans; in fact, they have girdled the whole earth. Considering the Atlantic as a great lake, narrowest within the tropics, we might naturally expect that there would be some resemblance between the flora of Brazil and the west coast of Africa, and such is really the case. Not only is this perceptible in the mangrove swamps, but even in the forests away from the coast. The Pacific is so large that the west coast of South America has been little affected by Southern Asia, but its islands undoubtedly form one great botanical area, the result of wave-borne seeds. The coral animal creates an island, on which obviously no vegetation can grow, unless the germs are brought there in some way, and the power of enduring salt water becomes, therefore, of the utmost importance in plant distribution.

And here we may remark that these Pacific islands are highly favoured by nature. If we take a glance over the world, we find that the spontaneous vegetation can hardly support life. Agriculture is a necessity, for man could barely exist upon the wild fruits of Europe or America. But in the Pacific the cocoa-nut, which the waves have carried to every little islet, provides food and fresh water, which would at least preserve life even in the absence of anything else. The bread-fruit has probably been carried from island to island by man, and is therefore not so widely distributed; nature has done her work more completely with the cocoa-nut.

After the oceans, the great seas may be considered as mighty factors in plant distribution, and their shores as forming provinces of the vegetable kingdom. The Mediterranean is one which has a distinct flora on its borders, and the plants of the Caribbean Sea are equally characteristic. Great lakes are often connected with the watersheds of the rivers which flow into or through them, and they assist in distributing seeds from one to the other.

A beautiful illustration of the influence of water on plant distribution is furnished by the American water-weed (*Elodea Canadensis*), now so widely diffused through the canals and rivers of Great Britain. Some sixty years ago it was introduced in an unknown way from North America, and immediately it began to spread by means of the connecting channels between one river and another, possibly with the assistance of floods. Removed from its original environment, and free from the enemies by which it had hitherto been hampered, it seemed to have taken over a new lease of life. Every other water-plant went down before it, and soon it triumphed so far as to seriously impede canal navigation, and to render strenuous efforts necessary before it could be at all checked.

The removal of a tree or plant from one environment to another may be beneficial or the opposite; in most cases, however, the stranger in a strange land is less able to contend with the new enemies it encounters there than with those of its own home, to which it had become accustomed for long generations. The American water-weed in England and the thistle in the antipodes are examples of the possibilities of many species, were they not subject to a thousand adverse influences. If every seed of even one species were to germinate and grow, in a few generations it would cover the whole of a region not shut off by impassable barriers.

We have already seen that there are few impassable barriers over which some seeds at least cannot be carried. Birds cross wide seas, carrying with them, sometimes in their crops and sometimes even attached to their feathers, the germs of plants and trees which may grow if the climate is suitable. In the Pacific, sea-birds are utilised by a shrub (*Pisonia inermis*), which has its seeds carried from island to island hooked on to their plumage. On land a similar result is produced by means of wild animals.

Man carries with him wherever he goes, either intentionally or otherwise, a host of weeds—hardy creatures that will not be suppressed—as well as some useful plants. Perhaps the most widely dispersed is the greater plantain (*Plantago major*), which has been called the "white man's footprint" by the North American Indian. Few of the weeds of temperate climates can endure the heat of the tropics, but this is an exception, for we have seen it in a little garden fifty miles up the Demerara river. It does not appear, however, to have much vitality within the torrid zone, but the wonder is that it can live there at all.

Where did the weeds come from? Many of them can only exist in connection with man; they appear to be as dependent upon him as the corn in his fields, the fruit-trees in his orchard, or the vegetables in his kitchen-garden. Yet he does not want them; they are pests to be extirpated wherever found, if possible, and, when they raise their heads in defiance, to be abused and cursed. No wonder that the Hebrews said that the Creator put them here to hamper man's work.

Speaking of the dawn of history, Hehn says in his "Wanderings of Plants and Animals":—"The swine found plenteous nourishment in the abundant acorns: the dog guarded the flocks; wild honeycombs furnished wax and honey; wild apple, pear, and sloe trees afforded hard, sour fruits; at the stag and boar, wild ox and ravening wolf, the arrow sped from the bow, or the sharp, stone-tipped spear was hurled. Game and domestic animals furnished all that was needed: skins for clothing, horns for drinking-vessels, sinews and entrails for bow-strings, bones for tools and their handles." A wandering life was not consistent with the development of agriculture; there were no cultivated fields, no orchards, no gardens, and there could be no roadsides for the weeds.

In Guiana we have the man of the forest, but he has advanced beyond the first stage by learning to open out a little clearing, in which to grow cassava and a few other food-plants. Even here, however, there are weeds; plants which are as characteristic of his little patch of ground as the poppy is of the corn-field. Where they come from and how they come is a mystery. They are not found in the forest, and they certainly have not been knowingly carried from one clearing to another. The weeds of the negro's garden on the bank of the river are similar to those of the plantations on the coast, but those of the red man's provision ground are distinct. Given certain conditions and they come to the front; without these they cannot exist.

The Indian has roads, or rather paths, through the forest, but they are too narrow for weeds. Here and there, however, where they cross the open sand-reef, a group of pine-apples may be seen, probably the result of the top of a fruit thrown away some time or other, perhaps centuries ago, by an Indian when passing; it has thus become a wayside plant. This is the only representative of that great army of pests which follow civilised man in his wanderings.

The most prominent thing in a civilised country is the road, and the possibility of controlling a great area of territory depends upon it. How could the Roman Empire have been possible without its beautiful system of ways! Some still exist in different parts of England, and where they pass over moors and downs, they can still be recognised even when disused. Such is also the case with Indian paths under similar conditions. Although so narrow as to allow only one person to walk behind another, in what is called Indian-file, they may sometimes be distinguished on the barren sand-reef after they have been obliterated in the forest. When we see a party of Indians passing along the streets of a town, and observe how one walks behind the other at equal distances, we can appreciate the fact that their only roads at home are paths where any other manner of travelling is impossible.

The only domestic animal belonging to the man of the forest is the dog, and no doubt he assists in the distribution of seeds. Cattle, horses, and more especially sheep, are the great weed-carriers in more civilised countries. Man himself unconsciously does something, but his flocks and herds are the principal agents. By their means the earth is girdled by three great zones of weeds, those of the northern and southern temperate regions, and that of the tropics. We find them in our gardens and fields, and they extend along the roadsides, to be carried from one country to another in fodder, packing materials, ballast, and in fact almost everything. By studying them carefully we can in some cases indicate the course of migration. De Candolle has written about the "Origin of Cultivated Plants;" the story of the weeds is quite as interesting.

While the ocean assists in the dispersal of some seeds, it acts as a barrier to others. But few species can endure a long immersion in salt water, and it has followed, therefore, that many islands, while partly occupied by plants which have a distribution only bounded by the zone in which they are situated, have also peculiar species to be found within their coasts, but nowhere else. Some of these plants are endemic to one island of a group, and we may therefore presume that they have been developed there through long ages of isolation. This matter of insular floras is a very interesting one, but as yet there has been no satisfactory explanation of its peculiarities. Another great problem in plant distribution is the resemblance of the vegetation of one mountain peak to that of another, when perhaps the distance between them is so great as to be virtually impassable by any ordinary means.

Taken altogether, the study of plant distribution is peculiarly fascinating. On the one hand it goes to prove that some of our fruit-trees came from China in an age of which we know nothing. The peach is an example; the Greeks and Romans spoke of it as a Persian fruit, because they probably got it through that country, but its original home was almost certainly either China or Japan. When the means of communication between Asia and Europe was by caravans, plants were distributed from one country to another, those of the Mediterranean being carried to the far East, and those from China brought into Greece, Egypt, and Italy. Later, after the discovery of America, tobacco, which was almost certainly unknown to the Old World, was carried by sea into every country, to become such a necessary to the Mussulman that he ascribes its discovery to Mohammed. So quickly did the habit of smoking prevail, that doubts have been thrown upon the evidence that it could only have been known after the first voyage of Columbus.

Coffee is an example of a plant which appears to have been used in Abyssinia from very early times, and yet it was hardly known in Europe before the beginning of the seventeenth century. It was in use among the Arabs for perhaps a thousand years, and yet no one introduced it into Christendom. Now it is in cultivation throughout the tropical world. The fortunes of war brought the mango into the British West Indies. A French vessel carrying some young trees from Bourbon to St. Domingo, in 1782, was captured by the British and carried to Jamaica, from whence the trees were distributed to the neighbouring islands so quickly that by the end of the century it was almost common. The bread-fruit will always be connected with the story of the mutiny of the *Bounty*, Captain Bligh, and the Pitcairn islanders. After his failure through the mutiny he again proceeded to Otaheite, and in 1793 landed 153 plants in the island of St. Vincent, from whence it soon spread throughout the West Indies. Strange to say, however, the negro has never taken to the fruit; his staff of life is the plantain.

While some plants have been quickly appreciated, others remain virtually unknown for ages. If its produce once becomes popular a plant spreads at once; otherwise it is confined to one people for perhaps thousands of years. Tea was a common drink in China long before the Christian era, but none of the caravans appear to have brought it into Europe; yet the American maize was so soon appreciated in the East that Europe knew it best under the name of Indian-corn, and the French called it Turkey wheat.

CHAPTER XIII

THE WORK OF THE FORESTER

FORESTRY, the art of planting trees for man's benefit, has latterly become of very great importance in civilised countries. As we have already hinted, this useful art, like agriculture, endeavours to protect certain species at the expense of others; in fact, to eliminate the struggle for life altogether. It does not aim to let the strongest survive, but to perpetuate only those which have been found beneficial in some way to man, or, in towns, that satisfy his ideas of fitness or æsthetic beauty. Like agriculture, forestry must take account of climate, soil, and situation, as well as the object for which the trees are planted. For example, *Eucalyptus globulus* has been recommended for its sanitary influence, and large plantations have been made in Italy with very good results. Pine forests are also considered to assist in making a district healthy, but as the trees flourish best on high ground, they can hardly

A FOREST ROAD.

be introduced in the same way as the Eucalyptus. For boulevards in cities the greatest care must be taken in selecting species, as so few trees are suitable in every way. Some spread too much, and others that have not this drawback cannot endure the smoke and dust. To plant a fine avenue only to see one tree after another die is disheartening, and therefore too much care cannot be exercised at the beginning. To advise on these and a hundred other matters the professional forester has become a necessity in every civilised country.

In planting new woods and forests certain ends must also be kept in view. Although we live in an iron age, wood is still necessary, and it is the business of the forester to find out what trees are likely to be most valuable, and if these are suitable to the tract of land to be planted. He must also consider the means of transport, the cost, the probability of competition in the timber market, and in fact all possible difficulties and drawbacks, as well as advantages.

In some places screens will first have to be planted to keep off cold and dry winds from the young plantations; these must be formed of trees which grow quickly and which may in some cases be of little value. Then the land must be prepared, and the young trees, which should, in some cases at least, have been raised in nurseries, must be planted out. The order of planting and the distances apart have to be considered, as well as the question of whether one or more species should be used. Certain trees, such as the larch, may be cut when young for sale as poles, and these may therefore be planted more thickly than would otherwise be desirable.

Timber as a rule is more appreciated when it is straight and free from knots, and for this reason close planting is more desirable, especially at the beginning; when the trees begin to get crowded they may be thinned. Whether a plantation should be of one species or several will largely depend upon circumstances. Some places, like the sides of hills, are best suited to pines, and these may be planted rather close; others, such as low grounds that are damp, are better suited for deciduous trees, and may be more open. In coffee and cacao plantations what are called "tree mothers" are used, to give a partial shade; something similar is desirable for a time in the young woods of temperate climates.

Taken altogether, the advantages of mixed planting override those of "pure woods," for by it a larger number of trees to the acre may be grown. Some species will have their roots wide-spreading, others penetrate to a greater depth. Then the foliage will differ, and the manner of branching allow room for different kinds growing up between, and as long as these are not permitted to smother each other this may be permitted.

Having eliminated the struggle for life between tree and tree as far as possible, the forester must next proceed to protect the wood against man and other animals. We have already dealt with the great enemy, fire, which is purely the result of man's handiwork, but there are other agencies of his in civilised countries, such as smoke and the acid fumes from certain manufactories, which are highly destructive to trees. The young plantation may also be seriously injured by rabbits and the larger herbivorous animals, but these latter can be easily excluded.

Not so easy to control, however, is the host of insect enemies. Beetles, perhaps, are the most destructive; as larvæ they attack the vital part of the exogen, the bark and young wood everywhere, and in the tropics the apex of the stem of the palm, which they kill almost immediately. The larvæ of moths are quite as destructive, some of them playing sad havoc with the pine forests of Europe. From 1888 to 1891 the caterpillars of the nun moth appeared in such great numbers in South Germany that large tracts of spruce were denuded of their leaves, and ultimately killed. Over fifty million cubic feet of timber had to be cut to prevent utter loss, and the forests were seriously damaged.

Fungi are perhaps the most insidious foes to trees, and up to the present the forester has been unable to cope with them. No doubt their presence depends upon adverse influences of various kinds; in fact, they are evidence of the imperfection of all our care to eliminate the factors which make up the struggle for life. Like disease in animals, the ravages of fungi commence before they can be detected, and it is not until the tree obviously begins to suffer that an ordinary observer sees that anything is wrong. A lover of trees, one who has his heart in his profession as a forester, will know what is going on, but many persons in charge of woodlands only find it out when all possibility of help is gone.

In most woods we see trees rotting near the ground, some with holes in the stems full of water, branches dry, withered, or fallen, and leaves and fruit turning yellow and dropping before their time. All these are signs of disease, and when it has gone on for some time the bark and wood will be bored by grubs, and perhaps hollowed out here and there by wood-peckers in search of them. Excessive growths of lichens also denote weakness.

Overcrowding is responsible for many of these diseases, and bad drainage for others. Deciduous trees in winter cannot distil off the water from about their roots ; the ground becomes sour and the roots die, notwithstanding the strenuous efforts of the tree to produce new ones. In most cases of disease in young trees the spread of mortification can be arrested by cutting off a limb, or by root-pruning ; but old trees, unless they are a part of the landscape, have to be felled. Some which are interesting for their age or associations may have their lives prolonged by plugging the hollows, after a thorough cleaning, but as a rule the disease may be looked upon as infectious, and as such every effort must be made to prevent its spreading.

Larvæ of moths and butterflies are very destructive to trees. They eat the foliage until the whole tree is often quite bare, and give it such a check that in many cases it dies. Cockchafers are injurious to the roots as grubs, and to the leaves as perfect beetles.

In the tropics the great pests are the Coccideæ, or scale insects, which are well known also in English conservatories. Insufficient light and air are the predisposing causes of the great development of these tiny blood-makers. In connection with them come the fungi; in the case of the mango blight, there is a pretty, star-like scale on the under surface of the leaves and a black fungus on the upper. It does not appear, however, that the latter begins to show itself until the tree is weakened; there must be something the matter before the leaves form a suitable nidus for the pest. Like many of those diseases which affect man, they have no power until something paves the way. In towns smoke and dust choke the pores, and the absence of sunlight and pure water is as injurious to the tree as to man. In towns, also, leakage from gaspipes and sewers poison the trees through their roots, and latterly we are beginning to hear of their being killed by electricity, from imperfect insulation of the lighting-wires.

Tree-planting has lately been receiving much attention, especially since indiscriminate felling has caused a scarcity of timber in many countries. At first the forest is in the way, and must be got rid of at any cost, quite regardless of the wants of future generations. It gives place to corn-fields and meadows, until by-and-by the agriculturist feels the want of what he once so ruthlessly destroyed. Then he begins to plant, but as it takes many years for a seedling to grow big enough for timber, it has become necessary to urge upon those who have trees already not to be too hasty in turning all their woodland into open fields. Forests, when judiciously and economically managed, are not only useful but profitable; in some districts they may pay as well as corn; in fact, better if the land is poor. The landed gentry of the United Kingdom found it desirable to commence tree-planting in the early part of the last century, with the result that denudation was checked to a great extent; now the people of the United States are beginning to feel that they have been neglecting one of their great sources of wealth, and are doing their best to stir up public opinion in favour of preserving what are left and planting more. Nowhere in the world, perhaps, has so much attention been paid to this matter of tree-planting as in France. Paris has her boulevards, the admiration of every stranger, but it is in the Landes where the most gratifying results have been obtained.

These Landes are little better than deserts, blasted heaths, and morasses. Covering nearly three million acres on the borders of the great wine country, they stretch along the coast of the Bay of Biscay. All along the shore are sand-dunes, in strips and ridges, behind which come great pools choked with willows and sedges. The rainfall is heavy, but on account of the impenetrable subsoil and the obstruction of the dunes it cannot run off, but forms these morasses, which are dried up in summer and help to make the country unhealthy. This water is, of course, undrinkable, and that obtained from artesian wells is little better.

The inhabitants of this region are poor. Here and there a hut of rough stones, roofed with sods, stands in the midst of an almost barren field, which is liable to be overflowed by the shifting sands at any time. When the land wind blows they are driven into the sea, only to be washed up and sent back again by the gales from the Bay of Biscay. In the absence of protective measures they often cover the little farms of the poor inhabitants, who are thus prevented from making any real progress.

Down to about a century ago nothing had been done to reclaim this dreary waste. In 1789, however, the Government appointed M. Bremontier, a forest officer, to make an attempt to stem this billowy sea of sand. He commenced the work by erecting screens of boards or hurdles, treating the dunes almost as if he were making a dam to keep out the sea. Behind these he planted seeds of broom, mixed with those of *Pinus pinaster*, and littered the seed-beds with pine-branches, which had to be pegged down to prevent their being blown away. The broom grew quickly, and by the end of the year it afforded some protection to the young pines, and allowed a second zone to be planted under their lee. Finally the trees grew larger, smothered the broom, and by holding the sand together effectually checked its movements.

As may be supposed, the whole of the Landes could not be reclaimed at once, but nevertheless the work has been carried on year after year, until it is beginning to make an impression upon a very large stretch of country. The extent of land reclaimed amounts to over a hundred thousand acres, and behind this the inhabitants are quite free from the old danger. Besides their keeping back the sand, the pine forests, which of course will bear judicious thinning, have become the source of a productive industry, the manufacture of resin, pitch, tar, and turpentine.

Latterly an attempt has been made in Algeria to check the sands of the Sahara by planting trees. This, no doubt, will be a work of great utility, but whether means will be provided for its accomplishment is doubtful. That it can be done is practically certain, but naturally the work would be expensive and take a long time. Something has been rendered necessary, for during late years large pasture lands have been covered with sand-drifts. M. Reynard, Sub-Inspector of Forests, writing upon this matter, said that the probable results of extensive tree-planting would be to render the climate more regular and more uniform, and also be the commencement of taking possession of Central Africa. The idea seems almost utopian; nevertheless the results would be so beneficial that we can only hope it will be tried.

On the shores of the Baltic there are sand-dunes similar to those of the Landes, and in 1795 Herr Soerin-Biorn, a burgher of Danzig, was entrusted with the work of checking a drift which threatened to choke up the river Vistula. By means of fences and sand-grasses the first check was given, and willows and alders enabled to grow up into a thicket behind. This work, however, only protected about a mile, and it became necessary from time to time to supplement it. Although the protection has not been carried out so well as in the French Landes, there is no doubt that the results have been of great advantage.

The forester has to undo the destructive work of his ancestors, who have been blindly interfering with the balance of life. What has taken place is so well stated by Schleiden, in his work entitled "The Plant," that we cannot do better than give two extracts:—

"Almost everywhere, in the great characters in which nature writes her chronicles, in fossilised woods, layers of peat, and the like, or even in the little notes of men—for instance, in the records of the Old Testament—occur proofs, or at least indications, that these countries which are now treeless and arid deserts—part of Egypt, Syria, Persia, and so forth—were formerly thickly wooded, traversed by streams now dried up, or shrunk within narrow bounds; while now the burning glow of the sun, and particularly the want of water, allow but a sparse population. In contrast, must not the jolly toper laugh, indeed, who looks from Johannisberg out over the Rhine country and drinks the health in Rüdesheimer to the noblest of the German rivers, if he recalls the statement of Tacitus, that not even a cherry, much less a grape, could ripen on the Rhine! And if we ask the cause of this mighty change, we are directed to the disappearance of the forests. With the careless destruction of the growth of trees, man interferes to alter greatly the natural conditions of the country. We can, indeed, now raise one of the finest vines upon the Rhine, where two thousand years ago no cherry ripened; but, on the other hand, those lands where the dense population of the Jews was once nourished by a fruitful culture are in the present day half deserts. The cultivation of clover, requiring a moist atmosphere, has passed from Greece to Italy, from thence to South Germany, and already is beginning to fly from the continually drier summers there, to be confined to the moister north. Rivers which formerly scattered their blessings with equal fulness throughout the whole year, now leave their dry and thirsty beds to split and gape in summer, while in spring they suddenly pour out masses of snow, accumulated in winter, over the dwelling-places of affrighted men. If the continual clearing and destruction of forests is at first followed by greater warmth, a more southern-like climate, and a more luxuriant thriving of the more delicate plants, yet it draws close behind this desirable condition another which restrains the habitability of a region within as narrow, and perhaps even narrower, limits than before. In Egypt, no Pythagoras need now forbid his scholars to live upon beans; long has that country been incapable of producing them. The wine of Mendes and Mareotis, which inspired the guests of Cleopatra—which was celebrated even by Horace—grows no more. No assassin now finds the holy pine grove of Poseidon, in which to hide and lie in ambush for the singers hastening to the feast. The pine has long since retired from the invading desert climate to the heights of the Arcadian mountains. Where are now the pastures, where the fields, around the holy citadel of Dardanus, which at the foot of the richly-watered Ida supported three thousand mares? Who can talk now of the Xanthus, with its hurrying waters? Who would now understand the Argos, feeder of horses?"

. . . . .

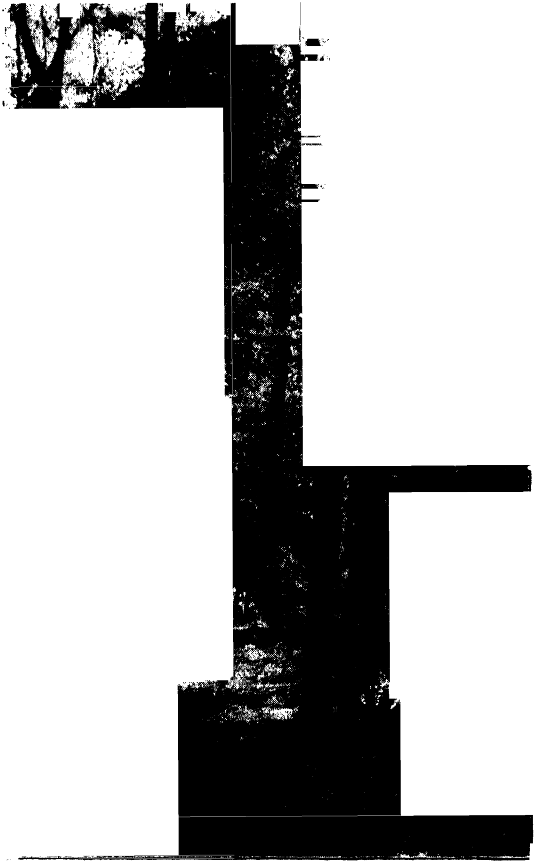
"A broad band of waste land follows gradually in the steps of cultivation. If it expands, its centre and cradle dies, and only on the outer borders do we find green shoots. But it is not impossible, it is only difficult, for man, without renouncing the advantage of culture itself, one day to make reparation for the injury which he has inflicted; he is appointed lord of creation. True it is that thorns and thistles, ill-favoured and poisonous plants, well named by botanists 'rubbish plants,' mark the track on which man has proudly traversed the earth. Before him lay original nature in her wild and sublime beauty; behind him he leaves the desert, a deformed and ruined land; for the childish desire of destruction or the thoughtless squandering of vegetable treasures have destroyed the character of nature; man himself flies terrified from the arena of his actions, leaving the impoverished earth to barbarous races or to wild animals, so long as yet another spot smiles before him in virgin beauty. Here again, in the selfish pursuit of gain, consciously or unconsciously, he begins anew the work of destruction. Thus did cultivation, driven out, leave the East and the deserts, perhaps previously robbed of their coverings. Like the wild hordes of old over beautiful Greece, thus rolls this conquest with fearful rapidity, from east to west through America; and the planter often now leaves the already exhausted land, the eastern climate becoming infertile through the demolition of the forests, to introduce a similar revolution into the far West. But we see, too, that the nobler races, or truly cultivated men, even now raise their warning voices, put their small hands to the mighty work of restoring to nature her strength and fulness in yet a higher stage than that of wild nature; one dependent on the law of purpose given by man, and arranged according to plans copied from the development of manhood itself. All this, indeed, remains at present but a powerless, and for the whole world an insignificantly small, enterprise, but it preserves the faith in the vocation of man and his power to fulfil it. In future times he will and must, when he rules, leads, and protects the whole, free nature from the tyrannous slavery to which he now abases her, and in which he can only keep her by restless giant struggles against the eternally resisting. We see in the grey cloudy distance of the future a realm of peace and beauty on the earth and in nature, but to reach it man must study long in the school of nature, and, *before all*, free himself from the bonds of that exclusive selfishness by which he is actuated."

CHAPTER XIV

FOREST PRODUCTS

THAT the products of the forest are of the greatest use to man is obvious. No doubt in the early ages of the world, before the cultivated fruits and the grasses which we now use for bread had been developed, man qualified his meat diet with the wild seeds and berries of the forest. We can hardly conceive of people nowadays living on acorns, but no doubt they were eaten by the Britons. In Guiana, when the cassava crop fails, mora and greenheart seeds are grated, washed, and made into bread by the Indians. Acorns would be certainly nicer than the first, and as for the second, they contain a bitter principle which can only be compared to quinine, which all the soaking in the world can hardly wash away.

The trees of South America produce very little in the way of food. There is, however, the Brazil nut and the Saouari, which, if they could be obtained in sufficient quantity



A TIMBER PATH.

everywhere, might provide the human inhabitants of the forest with a supply. But when it is considered that the former is one of the great trees of the forest, and that the large capsules are so far beyond the reach of any creature but a monkey, it will be understood that its usefulness for food is much depreciated. Some palms have a little pulp on the outside, hardly as much, in proportion to the nut, as that on the fruit of the hawthorn; and inside the hard shell is a white jelly like that of the young cocoa-nut: these are equally unsatisfactory. Most of the palms also have an edible heart or terminal bud, called cabbage, which might in an emergency prevent a man from starving, but certainly could not support life for any length of time. These, and a few berries, are all we find in the great forest in the way of vegetable food; in the tropics, as in temperate regions, man has had to cultivate plants for bread, and by artificial selection improve the varieties. Like wheat, cassava is not a wild plant, neither are yams or sweet potatoes found in the forest.

In Polynesia, besides the cocoa-nut, which is truly wild, the inhabitants have the bread-fruit, perhaps the only tree in the world which provides the staff of life over such a large area. Here also, however, we see the result of cultivation, for the variety most commonly used is seedless, and obviously the result of selection from the wild variety, which has seeds similar to those of the chestnut.

The sweet chestnut is used largely in the south of Europe for food, and in times of scarcity the acorns of species of oak, different to those found in England, and without their bitterness, are also used. Walnuts and beech-nuts, also, together with the nuts of the hazel, are eaten largely in different countries, and the seeds of pines in some parts of America, but none of these can be considered as forming the staff of life like the bread-fruit. The plantain and its variety, the banana, can hardly be called trees, for their stems are softer than cabbage-stalks, and these again must be considered as cultivated plants.

Forest trees, however, although they may not produce the staff of life, provide us with many useful adjuncts to the food-supply. The cocoa-nut provides oil, which when freshly drawn is used to an enormous extent in cooking, and the palm oil of West Africa is equally serviceable. All nuts have more or less oil combined with their albuminous matter, and this makes them very nutritious. The Indian butter-tree (*Bassia butyracea*) produces a fat from its seeds which is used to mix with ghee; but perhaps the most unique food-product of the forest is obtained from an allied species, *Bassia latifolia.* This, the Mahwa of Bengal, has sweet-tasted flowers, which are collected in large quantities, to be dried and stored for food, or eaten fresh. They are also used to prepare an intoxicating spirit, and are so very useful in certain districts that a threat to destroy the Mahwa trees will often bring an unruly tribe to reason. The flowers of *Bassia longifolia* are eaten in Malabar, and *Bassia Parkii*, the Shea butter-tree of West Africa, produces a fat as useful as that of the Indian butter-tree.

Although it can hardly be classed as a forest tree, the date palm is of such importance to the people of tropical Africa and Asia that it cannot be ignored. To the Arab and Moor its fruit takes the place of bread, and as it is the only food carried on long journeys, it is of the utmost importance. Horses, camels, and even dogs are alike partial to it, and it is hardly possible to conceive of a long journey over a desert being accomplished without it. Sugar is also obtained from it, as well as an intoxicating drink, which latter can also be procured by fermenting the sap obtained by tapping. As, however, fruit-bearing trees are too valuable for tapping, the Wild Date, a forest tree in India, is used. Sugar is also produced by the sugar-maple, some trees giving as much as thirty gallons of sap in one day. The Warrow Indians of Guiana use the eta palm (*Mauritia flexuosa*). The inner part of the stem produces a farinaceous food, and the pulp around the nuts a sweet or, if fermented, intoxicating beverage. Sago is obtained from the stems of several palms and cycads, and in India and Java it is largely used.

In the early ages of the world clothing was made from the inner bark or bast of trees. The simplest form of woman's dress is sometimes to be yet found in Guiana—a piece of monkey-pot bark about a foot long, by half that width, tied round the loins by a cord of the same bast. In the colder parts of the world skins were used, but in the neighbourhood of the Mediterranean the lime-tree bast was made into a mat-like covering by plaiting, as is done with other fibrous barks to-day in the Pacific Islands.

The man of the forest finds everything he needs within it. With the stems of trees he builds his house, and with leaves he thatches it. His weapons are wooden bows with fibre strings, and wooden clubs. His main-road is the river, and for travelling he hollows out great logs, or peels off the bark to make wood-skin canoes. The medicines he uses are also from the same source. Civilised man has gone to the forest and found a thousand useful products unknown to the savage. The forerunner of the great basket industry, which is now of so much importance, was the British coracle and the "suriana," in which the Guiana Indian women carry loads, and which is supported by a band of fibre across the forehead. Trees, vines, and bush-ropes, otherwise useless to man, thus become of the highest value. One of the latest developments in the direction of utilising trees that had been neglected is the manufacture of paper from wood-pulp. From this the spruce forests of Germany have become of far greater importance than formerly, and the more so from the fact that the branches as well as the trunks can be utilised. Many other soft-wooded trees will no doubt be found equally suitable for paper-making, and possibly from this cause be prevented from extinction.

The dug-out canoe or the wood-skin was in one piece, and only when the former was required to be built up were planks required. The Warrow Indians have arrived at this second stage of boat-building, and although they use no iron nails they make very strong boats, which they render waterproof with karamanni wax. Civilised man has gone further, with the result that pitch and tar, and resin and turpentine, have become of the utmost importance, notwithstanding that the building of iron ships has slightly depreciated their value.

India-rubber was used by the natives of tropical America at the time of its discovery, in a ball game, and down to about a century ago no one would have dreamed of such a development of its possibilities as is seen to-day. It is strictly a forest product, but no doubt in the course of a few decades the trees will be cultivated in many parts of the tropics. Although that from the Hevea of Brazil is considered the most valuable, other countries have rubber-yielding trees almost as important. For years these trees have been recklessly and needlessly destroyed, until now, when every day brings to light some new benefit to be derived from the product, it has become scarcer and scarcer. In 1830 only 464 cwts. were imported into the United Kingdom, while last year (1895) the exports alone of articles manufactured from it were valued at over a million sterling. Probably there is more india-rubber used in the United States than in any other country. In the month of March 1895 nearly four million pounds were imported, and this was but little above the average. This will give some idea of the development of what our grandfathers thought of only as a curiosity.

One of the most interesting stories of man's enterprise in the development of a forest product is that of the introduction of Cinchona trees from the New World to the Old. When it is understood that from the bark of certain species of Cinchona quinine is extracted, the importance of preventing wanton and careless destruction of the trees can be understood. Like the india-rubber collector, he who gathered the Cinchona bark from the slopes of the Andes cared little for posterity. The trees were needlessly destroyed until the price of quinine became so very high that imperfect substitutes were often used. This went on for many years, until efforts were made to introduce the trees into other countries by M. Hasskarl and Mr. C. R. Markham. Hasskarl was deputed by the Dutch Government in 1852 to go to Peru and collect seeds and plants of different species, which were to be sent to Java. This expedition was a success as far as obtaining the seeds and plants, but on account of various difficulties, mainly the growing of species poor in alkaloids, it could hardly be considered satisfactory. In the same year that saw the departure of Hasskarl the Governor-General of India said that, in view of the extreme value of quinine in the treatment of the fevers of that country, no more important plant than the Cinchona could be introduced there. Several efforts were therefore made to that end, but they were unsuccessful, until Mr. Markham was employed in 1860. The result of his expedition to Peru was the importation into India of some of the very best quinine-yielding species of Cinchona, which were planted in the hilly districts of Ceylon and South India and on the slopes of the Himalayas. From these plantations Java and other countries were supplied, and to-day quinine is about one-tenth the price that it was before this importation. If such grand results can be achieved in about thirty years, we may hope to see something similar from india-rubber cultivation.

The forest products used in tanning are also of the greatest importance. Galls and unripe pomegranates were used by the ancients, but neither the North American Indians nor savages generally appear to have ever discovered any process of preparing skins by similar means. The barks of all trees contain more or less of the material necessary for tanning, but the oak comes first, British trees alone supplying over two hundred thousand tons annually. Other barks, such as the mimosa from Australia, hemlock from North America, and mangrove from the tropics, are also largely used, together with galls, valonia, myrobalans, divi-divi, sumach-leaves, and the extracts known as cutch and gambir.

Economic forestry must take account of every product that can be utilised. First comes the timber, then the bark, and after these have been advantageously dealt with, fire-wood, charcoal, and potash from deciduous trees, and resin, turpentine, pitch, and tar from the pines and firs. In temperate climates, where forestry has become a science, this has been done to a very great extent; now the wider field of the tropics remains to be exploited.

The great zone of multiform woods no doubt contains thousands of species which will ultimately be found useful to man. Up to the present, however, with the exception of timber, spices, and drugs, all in comparatively small quantities, its valuable products are unknown. Civilised man is continually finding out something new; things which were at one time almost useless have become of the utmost importance to his welfare. In the same way that every British tree is peculiarly fitted for use in some particular industry, so also no doubt it will be found that those of the tropics have uses which only remain to be discovered to make them of vast importance. As far as man is concerned they are now useless, and the forests are in the position once occupied by those of Europe. Centuries passed before the value of the latter was discovered; probably a few decades hence we may find out many tropical products as useful as india-rubber.

CHAPTER XV

CONCLUSION

FROM the study of life in the forest many a lesson can be gleaned which is applicable to man. The two incentives to progress—the struggle for food, and the effort to get into a position where the procreation of the species may be carried on—is common to every living thing. In the woods of the north the trees seem to go on their way quietly ; in the tropical forest there is something like the turmoil of a dense population. No matter that the work is carried on silently, it is nevertheless arduous. The struggle for food between tree and tree, and that other battle for light, are as conspicuous to the naturalist, as the labourer's straining after fair wages, and the youth's efforts to gain a position where he can venture to marry. Many fail in both cases, but in the forest there is no relief for the unfortunate ; failure means death to the tree. Then, notwithstanding every effort to gain a place where it may open its flowers to the sun, and distribute its offspring in places where they may have opportunities of rising, it often lamentably fails.

Yet with all this the balance of life is evenly kept. No one species dominates over another, but each seems to have developed some particular quality which gives it an advantage, and enables it to exist notwithstanding the efforts of its rivals. It holds its own, but cannot get ahead, for the others are also on the alert, ready to smother it on the first opportunity. This has been going on for ages, with the result that aggressive and protective developments are continually taking place, and making every generation stronger and fitter to take its part in the battle. Man has gone through a similar training; but he differs from the tree in having gained an ascendency over other beings, which gives him an enormous advantage. Yet the Indian of the Guiana forest has taken but little part in this aggressive movement; if left alone, he remains as much a subject of the realm of nature as the tree. He neither increases nor diminishes to any great extent, but the balance slightly oscillates now and then, as the food supply becomes greater, or as famine, war, and disease come to the front. His wants are hardly more numerous than those of the tree. Food, and a shelter where he may bring up his little ones, are virtually the whole end and aim of his existence. Once he fought with other tribes, and this no doubt tended to his advancement; now, for want of such an incentive, he is degenerating.

The great problem looming in the future is that of the enormous increase of man in civilised countries. For good or evil this must go on, until perhaps the whole earth will be brought under control. The results will probably be so different from anything hitherto recorded, that it is impossible to foresee what will happen. Will man ruthlessly destroy everything that appears to stand in the way of his own interests? or will he find out how necessary other living things are to his comfort? Under natural conditions, checks of various kinds hamper the increase of one species at the expense of others. As we have seen, the tropical forest is the home of hundreds of species, no one of which is permitted to dominate over the others. Yet there is nothing like socialism; on the contrary, individuality, otherwise selfishness, comes to the front. However, like the inhabitants of a community, where each is trying to get on at the expense of the others, no single tree is really useless to the forest as a whole. Individuals make up the crowd, and the whole affect the climate as well as the rainfall of the country.

Man probably lived on the earth for ages without making any impression. He was in harmony with other beings, holding his place as one of them, but quite unable to become a "lord of creation." The "struggle for life" resulted in the survival we see to-day; a powerful animal, with capacities, as far as we can judge, far beyond those of any other. He is the outcome of a struggle with the elements, with ferocious beasts, and with his savage fellow-men. Will the coming struggle for existence, which is bound to result from overcrowding, also tend to raise him? Under natural conditions, the species or individual that cannot hold its own goes down before the others; civilised man, from feelings of benevolence, preserves the weak. Can we say that this will result in good?

When war and famine are prevented, as some anticipate will shortly be the case, what will be the result? Possibly a greater overcrowding than has ever yet been seen in the most densely populated country. Humanity will not allow nature's checks to be brought into play, and the struggle will become more and more intense. Presuming that the natural result is not hampered by legislation, the first effect will probably be to make marriage increasingly difficult. In the dense forest the trees prevent their rivals from coming up into the sunlight, where alone flowers and fruit can be produced. That marriage is much hampered nowadays is obvious; the struggling crowd of the city prevents many of its inhabitants from attaining suitable positions, and they remain hidden, as it were, under the shade.

Nature is a hard taskmaster, nevertheless the ultimate result of her processes is always good. But she is no respecter of persons; the benefit is to her whole realm. Individuals, and even races, will fall into the background and become extinct if too weak to contend with adverse circumstances. If a species neglects the use of any of its faculties, it becomes like the weakened tree of the forest. Its enemies crowd round and smother it, and its place is taken up by something more fitted to the conditions.

The great question appears to be this: Is nature right or wrong? For centuries theologians have been saying that our natural instincts and passions are to be suppressed in favour of humanity. Hospitals and asylums must be erected to preserve the weak in body and mind—those who when left alone would drop out of life's struggle, to the ultimate benefit of the community at large. None of the lower animals have gone farther on these lines than to protect their young and guard the community; even the natural man leaves the weak and infirm to die. Is, then, the civilised man a being so far above the others that he can afford to ignore all this? And when he does so, is it not at his own peril?

When we carefully survey the connection between man and the forest, we find the "lord of creation" has been making a series of mistakes from the very beginning of history. No doubt he is justified in utilising all the productions of the earth, but he can hardly be excused for the wasteful destruction which has been going on. Would it not be well, even for his own sake, that he should try to find out at first hand, as it were, how harmoniously nature is working for good? He has often altered the condition of a country, but has he ever made any real improvement?

Perhaps the reader will say that fields and parks are better than woods and jungles. From one standpoint this may be true; yet when we think of some of the countries which have been entirely denuded of forest, and of their consequent barrenness, it makes us almost despair. Putting man in the position of a being who has the right to *use* anything he finds suitable for his pleasure or profit, does not necessarily mean that he should ruthlessly destroy what he considers useless. Is he yet in a position to say what is good or evil? And, is it not a fact that nothing in the world is absolutely valueless?

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